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ASSESSING MOURNING DOVE POPULATION DECLINES: CHANGES
IN NESTING DYNAMICS AND THE ROLE OF PERCH SITES

by

Paul M. Meyers

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Fisheries and Wildlife

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1994

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I also thank with deepest sincerity and dearest regards, all of my friends and acquaintances who provided moral support, advice, wisdom, perspective, and distraction. I thank especially Gloria Collins.

Paul Meyers

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ABSTRACT

Assessing Mourning Dove Population Declines: Changes
in Nesting Dynamics and the Role of Perch Sites

by

Paul M. Meyers, Master of Science

Utah State University, 1994

Major Professor: Dr. Michael Conover
Department: Fisheries and Wildlife

I replicated a nesting study carried out 40 years ago in southern Utah to assess reasons for long-term population declines of mourning doves (Zenaida macroura) in the western United States. I compared current nesting patterns to similar data collected in 1952. I saw little difference in nest success and nest predation, but reproductive output and nest density decreased dramatically. The number of young fledged per pair of adults was only 64% of that estimated in 1952. A 1-2 week delay in the nesting season contributed to this decrease, but cannot explain it entirely. Nest density was about 20% of that in 1952 and total reproductive output for the study area about 12-19%. Underlying causes for these changes are uncertain, but patterns of delayed nesting, high nest abandonments, and low reproductive output

are similar to those seen in stressed bird populations (e.g., food/nutrient limitation or increased toxicant levels). Finally, highest nest density occurred in a habitat type (i.e., Chalk Creek) considered unimportant for doves in 1952. Nests in Chalk Creek suffered higher predation and abandonment rates than those in irrigation ditches.

I also examined the effect of perch sites on nest density and distribution in two ways. First, I demonstrated a significant correlation between nest density and perch site density in riparian plots. Second, I erected artificial perch sites in the second year of the study and recorded changes in nest densities. For the year of the study only, nest density was higher in the experimental plots, but the difference was not statistically significant. From the levels recorded the previous year, however, nest densities increased in the experimental plots and decreased in the control plots. This difference was statistically significant, suggesting that mourning doves use the presence of perch sites as cues for habitat selection. Finally, in comparing the presence of other avian species, I found significantly more blackbirds (Agelaius phoeniceus and Euphagus cyanocephalus) and western meadowlarks (Sturnella

neglecta) in experimental plots than in control plots.

(95 pages)

INTRODUCTION

Mourning doves (Zenaida macroura) are one of the most abundant birds in the United States (Robbins et al. 1986). Tomlinson et al. (1988) estimated an average fall population of 470 million birds in the lower 48 states. But in addition to being an abundant songbird, mourning doves are also an important game species. In some years, more mourning doves are harvested in the United States than all other game birds combined (Tomlinson et al. 1988). In recent years, an estimated 9% (45 million birds) of the fall population was harvested annually (Dolton 1994). In Utah alone, nearly 200,000 birds were harvested in 1990 (Mitchell et al. 1990).

Mourning doves breed throughout the lower 48 states, the southern sections of Canada, the Greater Antilles, Mexico, Bermuda, the Bahamas, and some sections of Central America (Dolton 1994). Two subspecies of mourning doves exist in the United States (Aldrich and Duvall 1958). Z. m. marginella occupies the western two-thirds of the nation, and Z. m. carolinensis occupies the eastern sections. An intermediate race exists in the zone of overlap (Dolton 1991). Mourning doves breed in a variety of habitats (Downing 1959, Caldwell 1964, Morse 1975, Howe and Flake

1989), and differences in behavior among populations are more likely an artifact of local conditions than subspecies type.

Mourning dove management has been divided into 3 geographic units in the conterminous United States. This division was based on banding evidence collected by Kiel (1959) suggesting 3 general mourning dove populations. The Western Management Unit (WMU) consists of 7 western states, including Utah. The Central Management Unit (CMU) comprises 14 central states, and the Eastern Management Unit (EMU) comprises 27 eastern states. Decisions regarding mourning dove management are made within units for each population. Although management is delegated to federal agencies under the Migratory Bird Treaty Act of 1918, state wildlife agencies actively participate in management and contribute to research and law enforcement (U.S. Fish and Wildlife Service 1975 cited from Tomlinson et al. 1988).

Mourning dove populations in the WMU have shown a downward trend since 1966 (Dolton 1994). Populations are monitored by a call-count survey, which serves as an index to the actual population. The survey consists of over 1000 randomly selected routes in which the number of doves heard in 3-minute time periods at 1.6-km intervals is recorded. Doves seen while driving are also recorded.

A consistent call-count method has been used since

1966. Analyzing data from 1966-94, Dolton (1994) found that the call-count estimates showed stable population trends for the EMU and CMU for the final 10- and 29-year periods. The WMU estimates, however, showed a significant downward trend for both doves heard and doves seen. Declines appeared to be the greatest in California and Oregon. In Utah, the population trend showed a decrease (though not significant) from 1966-94.

Reasons for the decline are unclear. The overall decrease may be due to degradation of wintering habitat in Mexico. However, Tomlinson (1989) examined banding recoveries in Mexico and reported that the largest percentage of birds from both the WMU (62%) and CMU (77%) winter in the same area (the Western Highlands region). Therefore, if wintering conditions were the reason for the decline, one might expect a concomitant decline in the central dove population. This has not occurred. These data do not rule out winter mortality completely, however, as a moderate percentage (38%) of the WMU doves winter outside the common area. In addition, lower juvenile survivorship plus a shorter overall breeding season (Tomlinson et al. 1988) may make the WMU population more sensitive to increased winter mortality.

Many factors in the U.S. also may account for the decline. Large-scale habitat change due to development and

changing land-use patterns may reduce both breeding habitat and food supply. Other factors include increased pollutant levels, increased predation, hunting, and large-scale climate change due to global warming. At the inception of this study, none of these factors appeared prominent.

The large scale of the population decline and its pattern of decrease make analysis difficult. The drop in numbers is not characterized by dramatic fluctuations from year to year but by a gradual decline. Causes for this type of decline are difficult to assess because no single event stands out. To approach this problem, I chose 2 methods.

First, I investigated changes that have occurred over the period of decline. To do this effectively, I needed a reference point before the decline began. In 1951 and 1952, Dahlgren (1955) conducted a mourning dove population study near Fillmore, Utah, in which he recorded calling counts, breeding season length, nest density, nest success, food habits, nest attributes, reproductive output, incidence of trichomoniasis, and vegetation use. In 1992 and 1993, I returned to this same study site to compare current population data. I focused attention on nesting ecology, with specific intent to investigate changes in nest density and nest success and explain mechanisms for perceived changes.

Second, I searched for possible habitat limitations the

first year of my study. Nest distribution showed the existence of a large amount of apparently suitable nesting habitat that was unused by the doves. Most of this habitat was devoid of trees. Further observations of nest-site selection showed that nests were invariably placed next to prominent perches protruding ≥ 2 m above the surrounding vegetation. Many researchers have speculated that perch sites are important components of avian habitat (Lack and Venables 1937, Kendeigh 1941, Hilden 1965, Zimmerman 1971, Wiens 1973, Knodel-Montz 1981, Castrale 1983), but there have been no attempts to study their effect on nest density and distribution.

My intention for this investigation was to discover reasons for the population decline in Fillmore and to point directions for further studies on other populations. It is hoped that my findings can be verified throughout the West to develop broad-scale patterns of population dynamics.

LITERATURE CITED

- Aldrich, J. W., and A. J. Duvall. 1958. Distribution and migration of races of the mourning dove. *Condor* 60:108-128.
- Caldwell, L. D. 1964. Dove production and nest-site selection in southern Michigan. *J. Wildl. Manage.* 28:732-739.

- Castrale, J. S. 1983. Selection of song perches by sagebrush-grassland birds. *Wilson Bull.* 95:647-655.
- Dahlgren, R. B. 1955. Factors affecting mourning dove populations in Utah. M.S. Thesis, Utah State Univ., Logan. 93pp.
- Dolton, D. D. 1991. Mourning dove breeding population status, 1991. U.S. Fish Wildl. Serv., Laurel, Md. 14pp.
- Dolton, D. D. 1994. Mourning dove breeding population status, 1994. U.S. Fish Wildl. Serv., Laurel, Md. 19pp.
- Downing, R. 1959. Significance of ground nesting by mourning doves in northwestern Oklahoma. *J. Wildl. Manage.* 23:117-118.
- Hilden, O. 1965. Habitat selection in birds. *Ann. Zool. Fenn.* 2:53-75.
- Howe, F. P., and L. D. Flake. 1989. Nesting ecology of mourning doves in a cold desert ecosystem. *Wilson Bull.* 101:467-472.
- Kendeigh, S. C. 1941. Birds of a prairie community. *Condor* 43:165-174.
- Kiel, W. H., Jr. 1959. Mourning dove management units--a progress report. U.S. Fish Wildl. Serv. Spec. Sci. Rep.--Wildlife 42. Washington, DC. 24pp.

- Knodel-Montz, J. J. 1981. Use of artificial perches on burned and unburned tallgrass prairie. *Wilson Bull.* 93:547-548.
- Lack, D., and L. S. V. Venables. 1939. The habitat distribution of British woodland birds. *J. Anim. Ecol.* 8:39-71.
- Mitchell, D. L., J. A. Roberson, H. M. Reeves, R. E. Tomlinson, and J. C. Bartonek. 1990. Utah upland game annual report. *Utah Div. Wildl. Res., Dep. Nat. Res. Publ. no. 91-4.* 226pp.
- Morse, D. H. 1975. Mourning doves breeding in an unusual habitat: the coastal spruce forest. *Wilson Bull.* 87:422-424.
- Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. *U.S. Fish Wildl. Serv., Spec. Sci. Rep.--Wildl.* 157. Washington, D.C. 196pp.
- Tomlinson, R. E. 1989. Unpublished memorandum to the Western Migratory Upland Game Bird Committee. Subject: Effects of conditions in Mexico on WMU mourning doves. April 19. Albuquerque, N.M. 2pp.
- Tomlinson, R. E., D. D. Dolton, H. M. Reeves, J. D. Nichols, and L. A. McKibben. 1988. Migration, harvest, and population characteristics of mourning doves banded in the Western Management Unit, 1964-1977. *U.S. Fish*

Wildl. Serv., Fish Wildl. Tech. Rep. 13. Washington,
D.C. 101pp.

Viens, J. A. 1973. Interterritorial habitat variation in
grasshopper and savannah sparrows. Ecology 54:877-884.

Zimmerman, J. L. 1971. The territory and its density
dependent effect in spiza americana. Auk 88:591-612.

ASSESSING MOURNING DOVE POPULATION DECLINES: CHANGES
IN NESTING DYNAMICS AFTER 40 YEARS¹

ABSTRACT

I replicated a nesting study carried out 40 years ago in southern Utah to assess reasons for long-term population declines of mourning doves (Zenaida macroura) in the western United States. I compared current nest success, predation rate, abandonment rate, nesting season length, vegetation use, reproductive output, and nest density to similar data collected in 1952. I saw little difference in nest success and nest predation, but reproductive output (i.e., the number of young fledged per pair of adults) and nest density decreased dramatically. Number of young fledged per pair of adults was only 64% of that estimated in 1952. A 1-2 week delay in the nesting season contributed to this decrease, but cannot explain it entirely. Nest density was only about 20% of that reported in 1952, and total reproductive output for the study area only 12-19%. Underlying causes for these changes are uncertain, but patterns of delayed nesting, high abandonments, and low reproductive output are similar to those seen in stressed bird populations (e.g., food/nutrient

¹Coauthors for this paper are Paul M. Meyers, William D. Ostrand, Michael R. Conover, and John A. Bissonette.

limitation or increased toxicant levels). Vegetation used for nesting changed from 1952 but also varied from 1992-93 and was probably not important to nest density. Highest nest density occurred in a habitat type (i.e., Chalk Creek) considered unimportant for doves in 1952. Nests in Chalk Creek suffered higher predation and abandonment rates than those in irrigation ditches.

Mourning doves are one of the most abundant birds in the U.S. (Robbins et al. 1986). Tomlinson et al. (1988) estimated an average fall population of 470 million birds in the lower 48 states. But in addition to being an abundant songbird, mourning doves are an important game species, as indicated by a tremendous yearly harvest. About 49 million doves are harvested each year (Keeler 1977), which, in some years, is more than all other game birds combined (Tomlinson et al. 1988). In Utah alone, nearly 200,000 birds were harvested in 1990 (Mitchell et al. 1990).

Two subspecies of mourning doves exist in the U.S. (Aldrich and Duvall 1958). Z. m. marginella occupies the western two-thirds of the nation, and Z. m. carolinensis occupies the eastern sections. An intermediate race exists in the zone of overlap (Dolton 1991). Although mourning doves breed throughout all of the conterminous states, banding evidence collected by Kiel (1959) suggests 3 general

populations associated with either the western, central, or eastern U.S. Decisions regarding mourning dove management are made separately for each population.

Mourning dove numbers are monitored by call-count surveys, which serve as indices to the actual populations. A consistent method for call counts has been used since 1966. From 1966-94, Dolton (1994) found that call-count estimates showed a significant downward trend for the Western Management Unit (WMU), while the Eastern and Central Management Units (EMU and CMU, respectively) showed stable trends for both the previous 10- and 29-year periods. Declines appeared to be the greatest in California and Oregon. In Utah, the population trend showed a decrease (though not statistically significant) from 1966-94.

Reasons for the decline are unclear. The overall decrease may be due to degradation of wintering habitat in Mexico. However, Tomlinson (1989) examined banding recoveries in Mexico and reported that the largest percentage of birds from both the WMU (62%) and CMU (77%) winter in the same area (the Western Highlands region). Therefore, if wintering conditions were the reason for the decline, one might expect a concomitant decline in the central dove population. This has not occurred. These data do not rule out winter mortality completely, however, as a moderate percentage (38%) of the WMU doves winter outside

the common area. In addition, lower juvenile survivorship plus a shorter overall breeding season (Tomlinson et al. 1988) may make the WMU population more sensitive to increased winter mortality.

Factors in the U.S., such as loss of nesting habitat, change in food supply, increased predation, hunting, and increased pollutant levels may also explain the drop in numbers. The large scale of the population decline and its pattern of decrease make analysis difficult. The decrease is not characterized by dramatic fluctuations from year to year but by a gradual decline. Causes for this type of change are difficult to assess because no single event stands out. However, a reference point before the decline began would allow one to look at changes that have occurred over this period of decline. Fortunately such a reference point exists. In 1951 and 1952, Dahlgren (1955) conducted a mourning dove population study near Fillmore, Utah, in which he recorded calling counts, breeding season length, nest density, nest success, food habits, nest attributes, reproductive output, incidence of trichomoniasis, and vegetation use. In 1992 and 1993, I returned to this same study site to compare current population data. I focused attention on nesting ecology, with specific intent to investigate changes in nest density and nest success and explain mechanisms for perceived changes.

I thank the Utah Department of Wildlife Resources for their generous support, especially J. A. Roberson and D. C. Larsen; T. D. Cook for his help in data collection; S. L. Durham for her statistical advice; J. A. Gessaman for his manuscript reviews; and A. B. Johnson and D. C. McMann for their logistical support.

STJDY AREA

The study site was located about 2 km northwest of Fillmore, Utah, in an area called the Old Fields. These fields were the first to be irrigated and farmed when the area was settled in the 1800's, and irrigation practices have changed little since that time. Chalk Creek, which ran through the area, was diverted into irrigation canals, and most of the farmland was irrigated by gravity flow.

The site was at the eastern edge of a broad, arid basin (Fahvant Valley). Rainfall averaged 37.9 cm per year. The specific area of research consisted of approximately 12.6 km of riparian vegetation (8.1 km irrigation ditch and 4.5 km creek) running through approximately 570 ha of farmland. The riparian vegetation consisted of a fairly continuous line of shrubs interspersed with trees. A few small areas along the irrigation ditches contained a second-story, closed canopy, but most of the canals were typified by shrubby vegetation.

Major vegetation in the irrigation canals consisted of willow (Salix sp.), squawbush (Rhus trilobata), wild rose (Rosa sp.), and golden currant (Ribes aureum). Major vegetation along Chalk Creek consisted of squawbush, interspersed in places with single, relatively tall (≥ 5 m) trees, such as willow (Salix sp.), cottonwood (Populus sp.), locust (Robinia sp.), and boxelder (Acer negundo).

Fields surrounding the canals consisted mostly of alfalfa, wheat, barley, and pasture--mainly rye grass. Unfarmed areas consisted of desert shrubs and grasses, including juniper (Juniperus utahensis), sagebrush (Artemisia tridentata), and cheatgrass (Bromus tectorum).

METHODS

Dahlgren (1955) found highest nest densities in the riparian vegetation of the Old Fields. Because he did not specifically define his 5.3 km census area, I began with a broad census of the entire study area and then focused weekly censuses on 5.3 km of ditch containing highest nest densities. Midway through the first field season, due to low incidence of nests, I expanded the weekly census to include all riparian areas (i.e., 12.6 km). Beginning 15 April 1992 and 1 May 1993 and continuing through 5 September, I searched for dove nests once per week by walking the riparian areas and agitating the vegetation with

a 2.5-m aluminum pole. To verify that the riparian areas still contained the highest nest density in the Old Fields, I walked 4 additional random transects once per month. These transects were 0.8, 1.8, and 4.0 km long and represented the major habitat types in the surrounding area: juniper-sagebrush, sagebrush, alfalfa, rye grass, barley, corn, and fallow fields.

I aged all dove eggs and nestlings (Hanson and Kossack 1957), and during searches, checked all previously found nests to construct full histories for each. I checked all nests on day 10 of the nestling period to determine fledging (Coon et al. 1981, Nichols et al. 1984).

Each failed nest was checked for cause of failure. If the eggs or nestlings were damaged or gone, I considered the nest depredated. If eggs, or nestlings ≤ 7 days old, were present without an adult, I considered the nest abandoned--mourning doves incubate and brood constantly (Dahlgren 1955, Sayre et al. 1980) through about day 7 of the nestling period. Abandoned nests were rechecked 1 week later to ensure the nest was abandoned. To determine whether abandonment occurred because of investigator disturbance, I rechecked the age of the egg or nestling when abandonment was first suspected. If development stopped within 1 day of the prior visit, I assigned the nest failure to investigator disturbance. I included these nests when comparing data to

1952, as Dahlgren made no distinction concerning abandonments. These nests were removed from all other analysis unless stated.

Many studies have examined the effect of human disturbance on nesting success of various bird species (Nolan 1963, Gottfried and Thompson 1978, Nichols et al. 1984, Westmoreland and Best 1985, Major 1990) with mixed results. To reduce the effects of investigator disturbance, I flushed the parent only the first time I encountered a nest. Subsequent checks were from a distance. Morrow and Silvy (1983:22) stated that "statistically equivalent data on nesting success of mourning doves can be obtained with a minimum of disturbance if only the fate of the nest is known" (not the fate of the individual nestlings).

I estimated the number of nesting pairs on the same dates that Dahlgren (1955) used. I did this by counting the number of nests in the study area and adding the number of new nests initiated the following week that I could not attribute to renesting (Dahlgren 1955). To estimate the number of nests produced per pair, I divided the total number of nests produced in the season by the peak number of nesting pairs (McClure 1943, Dahlgren 1955).

I calculated apparent nest success as the proportion of nests in which eggs were laid that produced fledglings. I also calculated nest success using the Mayfield method

(Mayfield 1961 and 1975, Miller and Johnson 1978). I calculated separate estimates for egg and nestling stages because the probability of survival was different in the nestling stage than in the egg stage. This phenomenon has been noted in other mourning dove studies (Dahlgren 1955, Best and Stauffer 1982, Morrow and Silvy 1982).

I multiplied the number of nests per pair by apparent nest success and number of young per nest (i.e., the number of fledglings divided by number of successful nests) to calculate the number of young fledged per pair of adults (Dahlgren 1955). I compared this value directly to that found in 1952.

Dahlgren measured some nest attributes, including nest height and plant species providing support and cover. I recorded these also. I measured nest height <4 m high with an incremented aluminum pole and higher nests with a clinometer. I also recorded the number of live and dead supporting branches. To determine whether changes in nest height were important to nesting success, I compared average height between successful and unsuccessful nests with a 2-tailed Student's unpaired t-test.

Dahlgren reported most of his data as means without standard deviations, so I assumed homoscedasticity and made mean comparisons with 2-tailed, Student's unpaired t-tests. I compared percentage data (e.g., nest success and predation

rates) with 2-tailed, 2-sample z-tests for proportions. I directly compared census data, such as number of nests and nest density.

I calculated the effects of a shortened season by constructing a flow chart of all possible combinations of successes and failures using probabilities calculated from the data I collected (Fig. 1). Actual figures include 62% chance of success, 38% chance of failure, 1.9 offspring per successful nest, and nest failure occurring on day 10 of the nest cycle. Fledging was assumed to occur on day 24 (Coon et al. 1981, Nichols et al. 1984). I assumed every pair renested 6 days after nest failure or fledging and that all pairs continued to nest throughout the season. Further, I assumed that neither success nor failure had an effect on the probability of future success. Finally, if a nest was initiated within the time limit being tested, I assumed that there was enough time left in the season to complete the nesting attempt.

I defined season length for nest initiation as the time in which 90% of the nests were initiated. To determine this, I excluded the earliest 5% and the latest 5% of the nests and took the season length to be the dates between the next earliest and the next latest nest initiations, respectively.

The only full-season data in 1992 came from a subset of

the study area, as I expanded the study site mid-way through the season. For this reason I used only 1993 data for most analyses. Unless noted, the ditches surveyed for the entire 1992 season were not significantly different from those same ditches in 1993 for all parameters under study. Also, unless stated, comparisons include 1952 data only, because 1951 data did not represent an entire season.

Finally, to determine whether the nutritional value of foods selected by doves in 1993 (Ostrand 1994) was less than that of foods selected in 1952 (Dahlgren 1955), I collected samples of Rocky Mountain bee weed (Cleome serrulata) from a site near Salt Lake City, Utah (about 200 km north of Fillmore) and compared the nutritional value to wheat collected near the study site. Samples were analyzed at USU Analytical Laboratories, Logan, Utah, using nitric acid perchlorate digestion (Jones et al. 1991) on an ICAP 9000 spectrophotometer, and total a Kjeldahl nitrogen test (Chapman and Pratt 1961).

RESULTS

I found 82 dove nests in 1992 and 112 nests in 1993. Nest density for comparable census areas dropped slightly (9.4%) from 1992-93. In 5.3 km of irrigation ditch, Dahlgren found 179 nests in 1951 and 252 nests in 1952. I found highest nest densities in the riparian areas. Only 1

nest occurred in sagebrush-Juniper, and none in sagebrush or agricultural fields. I found several nests away from the transects through reports from farmers and radio-telemetry. These nests occurred in pinyon-juniper, orchards, idle pasture, fallow fields, and town.

Overall dove reproductive effort decreased dramatically from 1952. Mated pairs in the irrigation ditches fledged an average of 2.5 young in 1993 and those in Chalk Creek fledged an average of 2.0. These figures are only 64% and 51% (respectively) of the 3.9 offspring per pair reported by Dahlgren (1955). Also, the overall nesting season appeared to start 1-2 weeks later than in 1952 (Fig. 2). The end of the season appeared premature in 1992, but when nests from the expanded study site were included, season termination was the same as for 1993.

Warm weather beginning 1 May 1952 may explain an early initiation of breeding that year (Fig. 3). However, if temperature were a factor, I would expect 1992's breeding season to begin earlier than 1993's. This did not occur.

Because doves nest sequentially throughout the season, later nest initiation may decrease the number of possible nests each pair could produce. Season length for nest initiation was 80 days (11 May-29 July) in 1952 and 70 days (18 May-26 July) in 1993. To include the expanded study site in 1992, I estimated season length for this year.

Estimates showed a 75-day season (22 May-4 Aug). Season length without the expanded study area was 62 days (20 May-20 July).

Under optimum conditions, I calculated that each pair could produce 4.6 young over 80 days available for nest initiations. At 75 days the breeding potential drops to 4.0 young per pair (i.e., a 13% reduction) and this figure remains constant to 62 days of season length.

In addition to low reproductive output, the study area in general did not support as many doves in 1992-93 as in 1952. The peak number of nesting pairs present in the irrigation ditches (Fig. 4) was about 38% (25% when adjusted for difference in sampling area) of that in 1952.

Highest nest density (15.1 nests/km in 1992 and 8.7 nests/km in 1993) occurred in Chalk Creek, though density varied along the creek, decreasing with increasing distance from town. Nest density among the irrigation ditches varied widely. Average nest density along these ditches was 9.0 nests/km in 1992 and 7.1 nests/km in 1993. Both of these averages were much lower than the 36.9 nests/km reported by Dahlgren (1955).

Dahlgren (1955) also stated that in addition to irrigation ditches, he censused 3 orchards and groves. Of these 3 stands, 1 remained intact in 1993, remnants remained of a second, and the third no longer existed. The remaining

grove yielded only 3 nests in 1993. Remnants of the second yielded 9 nests in 1993 (a relatively high number).

Apparent nest success in irrigation ditches was 62.0% (31/50), which was not significantly different ($Z = 0.53$, $P = 0.60$) from 57.9% reported by Dahlgren (1955). Overall (i.e., creek and ditches combined) apparent nest success was 50.6% (41/81), also not significantly different ($Z = 1.15$, $P = 0.25$) from that reported by Dahlgren. Nest success in Chalk Creek alone was 32.3% (10/31), significantly lower ($Z = 2.60$, $P = 0.009$) than in the irrigation ditches the same year. This difference was due entirely to high losses during the nestling stage in Chalk Creek. Hatching success (nests hatching eggs/nests that produced eggs) was nearly the same ($Z = 0.22$, $P = 0.83$) for both irrigation ditches and creek (66.7% and 69.2%, respectively). However, nestling success was much lower ($Z = 3.51$, $P < 0.0004$) in Chalk Creek than in the irrigation ditches (45.0% and 87.5%, respectively).

Mayfield estimates for survival in the irrigation ditches were as follows: 57.4% (95% confidence interval [CI] = 44.1-74.4%) for the egg stage and 87.0% (CI = 76.7-98.5%) for the nestling stage. Mayfield survival estimates in Chalk Creek were as follows: 55.9% (CI = 36.8-83.8%) for the egg stage and 41.4% (CI = 24.0-69.6%) for the nestling stage. Mayfield estimates were lower than apparent nest

success estimates for egg stages, but were nearly the same for nestling stages.

Inversely associated with nest success was predation rate. Dahlgren (1955) reported a predation rate of 35.7% (90/252) for 1952. Predation rate for 1993 was 32% (16/50) for the irrigation ditches, 58% (18/31) for Chalk Creek, and 42.0% (34/81) overall. When disturbed nests were included for comparison to the 1952 data, I found that neither ditch predation rate ($Z = 0.85$, $P = 0.40$) nor overall predation rate ($Z = 0.35$, $P = 0.73$) was significantly different than those in 1952. Predation in Chalk Creek, however, was significantly higher ($Z = 2.31$, $P = 0.02$) than in the irrigation ditches for 1993.

Abandonments were the other major cause of nest failure. Dahlgren reported an abandonment rate of 6.2% (24/389), including those abandoned due to his disturbance. Ditch abandonment rate in 1993 (including disturbed nests) was 11.1% (6/54), creek abandonment rate was 22.2% (8/36), and overall abandonment rate was 15.6% (14/90). Ditch abandonment rate was not significantly different ($\chi^2 = 1.83$, $P = 0.18$, $df = 1$) than in 1952. Overall abandonment rate was significantly higher ($Z = 2.97$, $P = 0.003$) than reported by Dahlgren (1955).

To increase sample size, the following abandonment rates include 1992 data. Ditch abandonment rate was

significantly higher in 1992-93 (12.9% or 9/70) than in 1952 ($Z = 1.99$, $P = 0.046$). Abandonments were nearly twice as high in Chalk Creek (25.0% or 16/64) as in the irrigation ditches (12.9% or 9/70) in 1992-93, but the difference was not significant ($Z = 1.80$, $P = 0.072$).

Average nest height ($\bar{x} \pm SD$) was 1.7 ± 1.2 m and was significantly lower ($T = 5.7$, $P < 0.001$, $df = 152$) than that in 1952 (2.35 m). Nest height in the irrigation ditches alone (1.8 ± 1.2 m) was also significantly lower ($T = 3.5$, $P < 0.001$, $df = 79$) than in 1952. For 1992-93, nest height in Chalk Creek (1.4 ± 0.8 m) was significantly lower ($T = 2.7$, $P < 0.01$, $df = 58$) than nest height in the irrigation ditches and probably reflected the difference in vegetation type. For successful nests, average height was 1.7 ± 1.2 m, and was not significantly higher ($T = 1.4$, $P > 0.10$, $df = 47$) than height of depredated nests (1.4 ± 1.0 m), though predation rate on ground nests, 60.0% (9/15), was higher than on elevated nests, 31.5% (52/165), $Z = 2.19$, $P = 0.026$.

Vegetation used for nesting changed slightly since 1952 (Table 1), with decreased use of all major vegetation types: willow, wild rose, and virgin's bower. Vegetation use also varied somewhat from 1992-93 for the irrigation ditches. Doves showed high use of dead vegetation: 54% of nests used dead limbs in 1992 and 53% in 1993. Also, spatial distribution of nest sites shifted slightly between these 2

years. Two ditch sections, barren of nests in 1992, had high nest densities in 1993. In one of these ditches, half the ditch had been razed between seasons. Apparently this improved access to the horizontal branches on the ditch-side vegetation.

I noted no difference in species of predators seen on the study site. I made no attempt to quantify predators; however, I was able to document 4 instances of egg predation (Hungarian partridge eggs) in mourning dove nests by using camera setups similar to those developed by Major (1991) but modified for use in actual dove nests (P. Meyers 1994 unpubl.). Two predation events were by ground squirrels. The other two were also by mammalian predators, which were probably also ground squirrels. Ground squirrels, specifically rock squirrels (Otospermophilus grammurus), were by far the most abundant predator in the study area. During the week in which the grain harvest began, a large pulse of food was added to the study site. Predation appeared to be affected by this food supply (Fig. 5).

The harvest also created a pulse of food for the mourning doves; however, it did not appear to affect reproduction. In 1992, dove reproduction increased slightly during the wheat and barley harvest (Fig. 2), though variation between weeks was inherently high. In 1993, grain harvest began after nest initiations subsided. Dahlgren

(1955) and Ostrand (1994) found wheat to be the dominant food source for doves. The nutritional value of wheat in the study area was lower than the native food source, bee weed, in protein and every trace mineral analyzed except aluminum (Table 2).

DISCUSSION

The most salient difference between Dahlgren's (1955) data and current data is the decrease in dove reproductive output. Combined with the lower nest density, the study area is producing about 12-19% of the doves it did in 1952.

Tomlinson et al. (1988) examined banding data collected from 1964-77 and determined that each breeding pair in the WMU must produce an average of 2.8 young per year to maintain a stable population. In Utah, where mortality is lower, the required average is 1.6 young per pair (Tomlinson et al. 1988). My estimates of 2.5 and 2.0 young per pair per year are below the reproductive benchmark for the western population, but just above for Utah.

The method I used for estimation of young per pair was developed first by McClure (1943) and has been used in many subsequent mourning dove studies (Cowan 1952, Dahlgren 1955, Randall 1955, Fichter 1959, Schroeder 1970). Although this number is appropriate to measure change, it may not be a realistic appraisal of the actual number of young per pair

of adults because it makes 2 untested assumptions. First, it assumes equal ingress and egress of mating pairs in the area. Second, it assumes that all pairs nest throughout the breeding season or that no previously unreproductive pairs replace birds that do terminate early. Evidence exists that hatching year birds can nest late in the season (Irby and Blankenship 1966, Mirarchi et al. 1980, White et al. 1987) but the magnitude of this occurrence is uncertain. Even if the exact number of young per pair is uncertain, however, given the magnitude of change in reproductive output, it is likely that the decrease in young fledged per pair is contributing to the low population levels in Fillmore.

The contribution of the delayed nesting season to lowered reproductive output is unclear. The estimate of a 13% decrease for a 9-day change was a maximum figure. The realized drop may be less if doves compensate through behavioral changes, such as nesting later into the season or decreasing time between renests. Season termination, however, was about the same as in 1952.

Shortening the season from 80 days to 75 produced an estimated 13% decrease in number of offspring per pair, yet shortening the season from 75 to 62 days produced no estimated change. This sharp drop and plateau is caused by the rigid assumptions of the model (e.g., predation always occurred on day 10, renesting always occurred 6 days after

previous nest termination, fledging always occurred on day 24). A model using exact daily probabilities of survival would produce a more gradual decline.

A problem exists in that Dahlgren's early season data included only 1 year, 1952, and there is no way to know whether this year was an anomaly. But whether or not the delay exists, it can only be partly responsible for the decreased reproduction.

Increased abandonments may contribute also, but overall nest success was not significantly different between the 2 time periods. Two other possibilities exist: 1) the doves abandoned the study area or terminated reproductive efforts early (probably after unsuccessful attempts), or 2) they took longer to renest. The pattern of nesting pairs present throughout the season (Fig. 4) is about the same as in 1952, suggesting that abandonment of reproductive efforts did not change. However, P. Meyers (1994 unpubl.), using radio-telemetry, documented the disappearance of 2 of 3 mated adults after unsuccessful nesting attempts (of nests that failed before 16 July). Despite the small sample, these abandonments of the entire area seem unusual for a species noted for nest-site fidelity.

Increased time between renesting is another likely possibility but requires more investigation to support. Although P. Meyers (1994 unpubl.) showed that 2 pairs did

delay renesting (4 weeks for 1 pair), most pairs renested 4-6 days later, which is the expected timing.

Although the ultimate cause of the decrease in reproduction was not investigated, the patterns I documented (i.e., delayed season, high abandonments, and low reproductive output) are similar to those of birds under stress (e.g., increased pollutants or food limitation). Several mourning dove and ring dove (Streptopelia risoria) studies have shown delayed reproduction due to ingestion of pollutants, especially polychlorinated biphenyls (PCBs) and dichlorodiphenylchloroethane (DDE) (Haegele and Hudson 1977, Farve 1978, McArthur et al. 1983, Tori and Peterle 1983, Koval et al. 1987). Koval et al. (1987) have further shown increased abandonments and increased time between renesting. Pesticides such as dichlorodiphenyltrichloroethane (DDT) are still used in Mexico. I have no data, however, that indicate the presence of elevated toxicants in Utah doves.

Some evidence exists, however, for changes in food and nutrient availability. Ostrand (1994) collected dove crop samples in Fillmore, Utah in 1992-93 and compared them to samples taken by Dahlgren (1955) in the same study area. Although both reported that wheat was overall the predominant food type, Dahlgren (1955) also reported that bee weed was the dominant early- and late-season food source. Ostrand (1994) found no bee weed present in dove

crops. This altered diet may indicate a loss of an important food and nutrient source. Bee weed is episodic in Utah, and again the problem exists of only 1 year's data in 1952. The plant was completely absent from the study area in 1992 and 1993. In 1993, I found a small cluster several kilometers west of the study site.

Whether this change in food supply has caused lowered reproduction is uncertain. However, food, protein, and nutrient supplies can drastically alter reproductive dynamics in birds (Simkiss 1961, Anderson and Stewart 1973, Jones and Ward 1976, Beckerton and Middleton 1982, Cain 1982, National Research Council 1984, Arcese and Smith 1988, Manjit and Boag 1990, Aboul-Ela et al. 1992, Richner 1992, and Robbins 1993) often in the patterns observed in Fillmore.

Interestingly, the dietary protein content in the wheat I collected is lower than optimal requirements for chickens, Japanese quail (National Research Council 1984), and bobwhite quail (Colina virginianus, Aboul-Ela et al. 1992), but the content in bee weed is higher or nearly sufficient for these species.

Aside from lowered reproductive output, the major change was in nest density. Ostrand (1994) replicated Dahlgren's transect survey for the same years as this study and found that counts compared to 1952 were about 30% in

1992 and 20% in 1993. These data agree with mine. Dahlgren's (1955) data may have overestimated nest density for the entire area because he surveyed only the most productive ditches, while I included many unproductive ditches. For 5.3 km of irrigation ditch, Dahlgren (1955) found a total of 36.9 nests/km. In 1993, by looking at 200-m blocks of riparian vegetation, I found some densities as high. When totaled, however, these blocks only constituted 1.2 km of widely scattered plots, which, again, is about 20% of that in 1952.

Ostrand (1994) stated that the linear distance of shrubby vegetation along the riparian corridors changed little between 1952 and 1993 for this same study area. I noted that a large excess of riparian habitat went unused though it appeared to be suitable for nesting. Although I conclude that nesting habitat is not limiting in this environment, a limitation of perch sites may exist (see chapter 2), which would reduce suitable nesting areas and therefore overall nest density.

Another significant change since 1952 is that nest density was highest in Chalk Creek in 1992-93. The significance of this apparent shift is that the probability of nest survival in Chalk Creek was much lower than that in the irrigation ditches. At first appearance, this suggests an ecological trap (Gates and Gysel 1978); however, the

excessive nest mortality was not likely a function of nest density itself. High nest densities also existed in the irrigation ditches but these nests suffered no increased mortality. Also, egg predation rates were nearly identical between creek and ditches, which suggests that a functional response does not explain the higher predation on nestlings. The pattern suggests the presence of a different type of predator. Physically, the creek had much steeper, sandier banks, which may have supported more burrowing predators. Also, the creek stopped running early, which made the inside banks (over which almost all nests were located) particularly accessible.

As in 1951-52, predation was the largest cause of nest failure. This is true for most species of birds (Lack 1954, Ricklefs 1969, see also Caccamise 1976, and Best and Stauffer 1982), and many biologists consider predation a significant evolutionary pressure in nesting ecology (Slagsvold 1982, Moller 1987). Overall predation rate, however, was remarkably similar during the 2 time periods. I do not consider predation a likely cause of the decline.

Although nest height was significantly lower than that in 1952, the actual difference in height was only 0.7 m and probably reflects a slight change in vegetation height or structure. This change is not biologically significant, however, as nest height was not important to nesting

success. These data agree with data collected by Yahner (1983) and Major (1990) but conflict with Best and Stauffer (1982).

The change in vegetation use also may indicate a change in species composition or successional stages from 1952. However, vegetation use changed from 1992-93 and throughout each season. As doves nest in a wide variety of habitat types (Downing 1959, Caldwell 1964, Morse 1975, Howe and Flake 1989), and have been shown to be extremely adaptable nesters (Soutiere and Bolen 1976), vegetation type used for nest support is probably not extremely important.

MANAGEMENT AND RESEARCH IMPLICATIONS

Overall, this study has demonstrated a significant change in reproductive output and nest density between 1952 and 1993. I have suggested that these changes have contributed to the population decline in Fillmore, Utah. I have further suggested several proximate causes for the changes observed. Specific studies into the presence of toxicants and food or nutrient limitations are now needed.

The question remains whether the patterns seen in Fillmore are representative of other dove populations in the western United States. Additional studies such as this one, concentrating on season length, nest density, and

reproductive output, are advised. Studies in the central and eastern United States are also advised. Similar changes may be occurring there despite stable population trends.

LITERATURE CITED

- Aboul-Ela, S., H. R. Wilson, and R. H. Harms. 1992. The effects of dietary protein level on the reproductive performance of bobwhite hens. *Poultry Sci.* 71:1196-1200.
- Aldrich, J. W., and A. J. Duvall. 1958. Distribution and migration of races of the mourning dove. *Condor* 60:108-128.
- Anderson, W. L., and P. L. Stewart. 1973. Chemical elements and the distribution of pheasants in Illinois. *J. Wildl. Manage.* 37:142-153.
- Arcese, P., and J. N. M. Smith. 1988. Effects of population density and supplemental food on reproduction in song sparrows. *J. Anim. Ecol.* 57:119-136.
- Best, L. B., and D. F. Stauffer. 1982. Factors affecting nest success in riparian bird communities. *Condor* 82:149-158.
- Beckerton, P. R., and A. L. A. Middleton. 1982. Effects of dietary protein levels on ruffed grouse reproduction. *J. Wildl. Manage.* 46:569-579.

- Caccamise, D. F. 1976. Nesting mortality in the red-winged blackbird. *Auk* 93:517-534.
- Cain, J. R. 1982. The effects of varying dietary phosphorus on breeding bobwhites. *J. Wildl. Manage.* 46:1061-1065.
- Caldwell, L. D. 1964. Dove production and nest-site selection in southern Michigan. *J. Wildl. Manage.* 28:732-739.
- Chapman, H. D., and P. F. Pratt. 1961. Methods of analysis for soils, plants, and water. Univ. of California, Riverside. 150pp.
- Coon, R. A., J. D. Nichols, and H. F. Percival. 1981. Importance of structural stability to success of mourning dove nests. *Auk* 98:389-391.
- Cowan, J. B. 1952. Life history and production of a population of western mourning doves in California. *Calif. Fish Game* 38:505-521.
- Dahlgren, R. B. 1955. Factors affecting mourning dove populations in Utah. M.S. Thesis, Utah State Univ., Logan. 93pp.
- Dolton, D. D. 1991. Mourning dove breeding population status, 1991. U.S. Fish Wildl. Serv., Laurel, Md. 14pp.
- Dolton, D. D. 1994. Mourning dove breeding population status, 1994. U.S. Fish Wildl. Serv., Laurel, Md.

19pp.

Downing, R. 1959. Significance of ground nesting by mourning doves in northwestern Oklahoma. J. Wildl. Manage. 23:117-118.

Farve, R. M. 1978. Effects of PCBs on ring dove (streptopelia risoria) courtship behavior. M.S. Thesis, Ohio State Univ., Columbus. 40pp.

Fichter, E. 1959. Mourning dove production in four Idaho orchards and some possible implications. J. Wildl. Manage. 23:438-477.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Gottfried B. M., and C. F. Thompson. 1978. Experimental analysis of nest predation in an old-field habitat. Auk 95:304-312.

Haegele, M. A., and R. H. Hudson. 1977. Reduction of courtship behavior induced by DDE in male ringed turtle doves. Wilson Bull. 89:593-601.

Hanson, H. C., and C. W. Kossack. 1957. Methods and criteria for aging incubated eggs and nestlings of the mourning dove. Wilson Bull. 69:90-101.

Howe, F. P., and L. D. Flake. 1989. Nesting ecology of mourning doves in a cold desert ecosystem. Wilson Bull. 101:467-472.

- Irby, H. D., and L. H. Blankenship. 1966. Breeding behavior of immature mourning doves. J. Wildl. Manage. 30:598-604.
- Jones, J. B., B. Wolf, and H. A. Mills. 1991. Plant analysis handbook. Micro-Macro Publishing, Inc. Athens, Ga. 213pp.
- Jones, P. J., and P. Ward. 1976. The level of reserve protein as the proximate factor controlling the timing of breeding and clutch-size in the red-billed quelea quelea quelea. Ibis 118:549-574.
- Keeler, J. E. 1977. Mourning dove (zenaida macroura). Pages 275-298 in G. C. Sanderson, ed. Management of migratory shore and upland game birds in North America. Univ. Nebraska Press, Lincoln.
- Kiel, W. H., Jr. 1959. Mourning dove management units--a progress report. U.S. Fish Wildl. Serv. Spec. Sci. Rep.--Wildlife 42. Washington, D.C. 24pp.
- Koval, P. J., T. J. Peterle, and J. D. Harder. 1987. Effects of polychlorinated biphenyls on mourning dove reproduction and circulating progesterone levels. Bull. Environ. Contam. Toxicol. 39:663-670.
- Lack, D. 1954. The natural regulation of animal numbers. Oxford Univ. Press, London. 343pp.
- Major, R. E. 1990. The effect of human observers on the intensity of nest predation. Ibis 132:608-612.

- Major, R. E. 1991. Identification of nest predators by photography, dummy eggs, and adhesive tape. *Auk* 108:190-195.
- Manjit, D. S., and D. A. Boag. 1990. The effect of food supplementation on the reproductive success of black-billed magpies pica pica. *Ibis* 132:595-602.
- Mayfield, H. F. 1961. Nesting success calculated from exposure. *Wilson Bull.* 73:255-261.
- Mayfield, H. F. 1975. Suggestions for calculating nest success. *Wilson Bull.* 87:456-466.
- McArthur, M. L. B., G. A. Fox, D. B. Peakall, and B. J. R. Philogene. 1983. Ecological significance of behavioral and hormonal abnormalities in breeding ring doves fed an organochlorine mixture. *Arch. Environ. Contam. Toxicol.* 12:343-353.
- McClure, H. E. 1943. Ecology and management of the mourning dove, zenaidura macroura (Linn.), in Cass County, Iowa. *Ia. Exp. Stn. Res. Bull.* 310:355-415. Ames, Ia.
- Miller, H. W., and D. H. Johnson. 1978. Interpreting the results of nesting studies. *J. Wildl. Manage.* 42:471-476.
- Mirarchi, R. E., P. R. Scanlon, R. C. Gwazdauskas, and R. L. Kirkpatrick. 1980. Gonadal and hormonal characteristics of juvenile female mourning doves in

- Virginia. Proc. Annu. Conf. Southeast Assoc. Fish Wildl. Agencies. 34:415-425.
- Mitchell, D. L., J. A. Roberson, H. M. Reeves, R. E. Tomlinson, and J. C. Bartonek. 1990. Utah Upland Game Ann. Rep. Utah Div. Wildl. Resour. Dep. Nat. Res. 91-4. 226pp.
- Moller, A. P. 1987. Egg predation as a selective factor for nest design: an experiment. Oikos 50:91-94.
- Moore, D. S., and G. P. McCabe. 1989. Introduction to the practice of statistics. W. H. Freeman and Company. New York, N.Y. 790pp.
- Morrow, M. E., and N. J. Silvy. 1982. Nesting mortality of mourning doves in central Texas. Proc. Ann. Conf. Southeast Assoc. Fish Wildl. Agencies 36:537-542.
- Morrow, M. E., and N. J. Silvy. 1983. A comparison of individual and nest survival of mourning doves and implications to nesting. Proc. Ann. Conf. Southeast Assoc. Fish Wildl. Agencies 37:19-22.
- Morse, D. H. 1975. Mourning doves breeding in an unusual habitat: the coastal spruce forest. Wilson Bull. 87:422-424.
- National Research Council. 1984. Nutrient requirements of poultry. Eighth ed. Natl. Acad. Sci., Washington D.C. 71pp.

- Nichols, N. D., H. F. Percival, R. A. Coon, M. J. Conroy, G. L. Hensler, and J. E. Hines. 1984. Observer visitation frequency and success of mourning dove nests: a field experiment. *Auk* 101:398-402.
- Nolan, V., Jr. 1963. Reproductive success of birds in a deciduous habitat. *Ecology* 44:305-313.
- Ostrand, W. D. 1994. Factors affecting mourning dove population declines. M.S. Thesis, Utah State Univ., Logan. 76pp.
- Randall, R. N. 1955. Mourning dove production in south central North Dakota. *J. Wildl. Manage.* 19:157-159.
- Richner, H. 1992. The effect of extra food on fitness in breeding carrion crows. *Ecology* 73:330-335.
- Ricklefs, R. E. 1969. An analysis of nesting mortality in birds. *Smithsonian Contrib. Zool.* 9:1-47.
- Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. U.S. Fish Wildl. Serv. Spec. Sci. Rep.--Wildl. 157. Washington, D.C. 196 pp.
- Robbins, C. T. 1993. Wildlife feeding and nutrition. Second ed. Academic Press, San Diego, Calif. 352pp.
- Sayre, M. W., T. S. Baskett, and K. C. Sadler. 1980. Radio-telemetry studies of the mourning dove in Missouri. Mo. Dep. Conserv. Terrestrial Ser. 9. Jefferson City. 17pp.

- Schroeder, M. H. 1970. Mourning dove production in a Kansas osage orange plantation. J. Wildl. Manage. 34:344-348.
- Simkiss, K. 1961. Calcium metabolism and avian reproduction. Biol. Rev. 36:321-367.
- Slagsvold, T. 1982. Clutch size variation in passerine birds: the nest predation hypothesis. Oecologia 54:159-169.
- Soutiere, E.C., and E.G. Bolen. 1976. Mourning dove nesting on tobosa grass-mesquite rangeland sprayed with herbicides and burned. J. Range Manage. 29:226-231.
- Tomlinson, R. E., D. D. Dolton, H. M. Reeves, J. D. Nichols, and L. A. McKibben. 1988. Migration, harvest, and population characteristics of mourning doves banded in the Western Management Unit, 1964-1977. Fish Wildl. Tech. Rep. 13. U. S. Fish Wildl. Serv., Washington, D.C. 101pp.
- Tomlinson, R. E. 1989. Unpublished memorandum to the Western Migratory Upland Game Bird Committee. Subject: Effects of conditions in Mexico on WMU mourning doves. 19 April. Albuquerque, N.M. 2pp.
- Tori, G. M., and P. J. Peterle. 1983. Effects of PCBs on mourning dove courtship behavior. Bull. Environ. Contam. Toxicol. 30:44-49.

- Weeks, H. P., Jr. 1978. Characteristics of mineral licks and behavior of visiting white-tailed deer in southern Indiana. *Am. Midl. Nat.* 100:384-395.
- Westmoreland, D., and L. B. Best. 1985. The effect of disturbance on mourning dove nesting success. *Auk* 102:774-780.
- White, L. M., R. E. Mirarchi, and M. E. Lisano. 1987. Reproductive capability of wild hatching-year mourning doves in Alabama. *J. Wildl. Manage.* 51:204-211.
- Yahner, R. H. 1983. Site-related nesting success of mourning doves and American robins in shelterbelts. *Wilson Bull.* 95:573-580.

Table 1. Percent of mourning dove nests found in various vegetation types. P-value denotes difference between 1952 and 1993.

| Species | 1952 Ditches n = 196 | 1993 Ditches n = 45 | 1992 Ditches n = 37 | 1993 Creek n = 37 | p-value |
|--|----------------------------|---------------------------|---------------------------|-------------------------|----------|
| Willow (<u>Salix</u> <u>sp.</u>) | 53.1 | 20.0 | 32.4 | 2.7 | < 0.0004 |
| Wild Rose (<u>Rosa</u> <u>fenleri</u>) | 21.9 | 8.8 | 21.6 | 0 | 0.047 |
| Currant (<u>Ribes</u> <u>aureum</u>) | 8.1 | 6.6 | 10.8 | 0 | a |
| Cottonwood (<u>Populus</u> <u>sp.</u>) | 5.1 | 11.1 | 2.7 | 0 | a |
| Locust (<u>Robinia</u> <u>sp.</u>) | 7.1 | 17.7 | 13.5 | 0 | a |
| Hawthorn (<u>Crataegus</u> <u>sp.</u>) | 6.1 | 11.1 | 2.7 | 0 | a |
| Poplar (<u>Populus</u> <u>sp.</u>) | 4.1 | 0 | 0 | 0 | a |
| Elm (<u>Ulmus</u> <u>sp.</u>) | 4.1 | 2.2 | 5.4 | 2.7 | a |
| Ash (<u>Fraxinus</u> <u>sp.</u>) | 0.5 | 6.7 | 8.1 | 0 | a |

(table continues)

| Species | 1952 Ditches <u>n</u> = 196 | 1993 Ditches <u>n</u> = 45 | 1992 Ditches <u>n</u> = 37 | 1993 Creek <u>n</u> = 37 | p-value |
|---|-----------------------------------|----------------------------------|----------------------------------|--------------------------------|--------------|
| Squawbush (<u>Rhus</u> <u>trilobata</u>) | 2.6 | 13.3 | 0 | 86.5 | ^a |
| Apple (<u>Malus</u> <u>sp.</u>) | 3.1 | 2.2 | 5.4 | 0 | ^a |
| Plum (<u>Prunus</u> <u>sp.</u>) | 0 | 2.2 | 10.8 | 0 | ^a |
| Virgins Bower (<u>Clematis</u> <u>lequstici-</u> <u>folia</u>) | 53.2 ^b | | 16.2 | | < 0.0004 |
| Bedstraw (<u>Galium</u> <u>triflorum</u>) | 0 | | 13.5 | | ^a |
| Virgins Bower and Bedstraw | 53.2 ^b | | 29.7 | | 0.054 |
| Rye Grass (<u>Lolium</u> <u>multiflorum</u>) | 0 | 0 | | 2.7 | ^a |
| Sagebrush (<u>Artemisia</u> <u>tridentata</u>) | 0 | 0 | | 5.4 | ^a |

^aPercentage too small for statistical analysis.

^bData from 1951 (i.e., late-season nests compared), n = 139.

Table 2. Nutritional content (% and mg/kg) of bee weed and wheat with dietary requirements (National Research Council 1984) for domestic chickens and Japanese quail.

| Nutrient | Bee Weed | Wheat | Domestic | Japanese |
|-------------|----------|-------|--------------|--------------|
| | | | Chicken | Quail |
| | | | Requirements | Requirements |
| Protein (%) | 18.75 | 9.2 | 14.5 | 20 |
| Ca (%) | 0.10 | 0.04 | 3.4 | 2.5 |
| K (%) | 0.49 | 0.29 | 0.15 | 0.4 |
| Mg (%) | 0.18 | 0.12 | 0.05 | 0.05 |
| P (%) | 0.37 | 0.29 | 0.32 | 0.55 |
| S (%) | 0.65 | 0.10 | | |
| Na (mg/kg) | 0.007 | 0.003 | | |
| Al (mg/kg) | 12.61 | 26.83 | 0.15 | 0.15 |
| B (mg/kg) | 20.81 | 10.12 | | |
| Fe (mg/kg) | 42.96 | 44.13 | 60 | 60 |
| Cu (mg/kg) | 18.87 | 6.53 | 8 | 6 |
| Mn (mg/kg) | 0.18 | 0.12 | 60 | 70 |
| Sr (mg/kg) | 17.38 | 3.21 | | |
| Zn (mg/kg) | 26.49 | 16.83 | 65 | 50 |
| Se (mg/kg) | 0.0 | 0.0 | 0.1 | 0.2 |

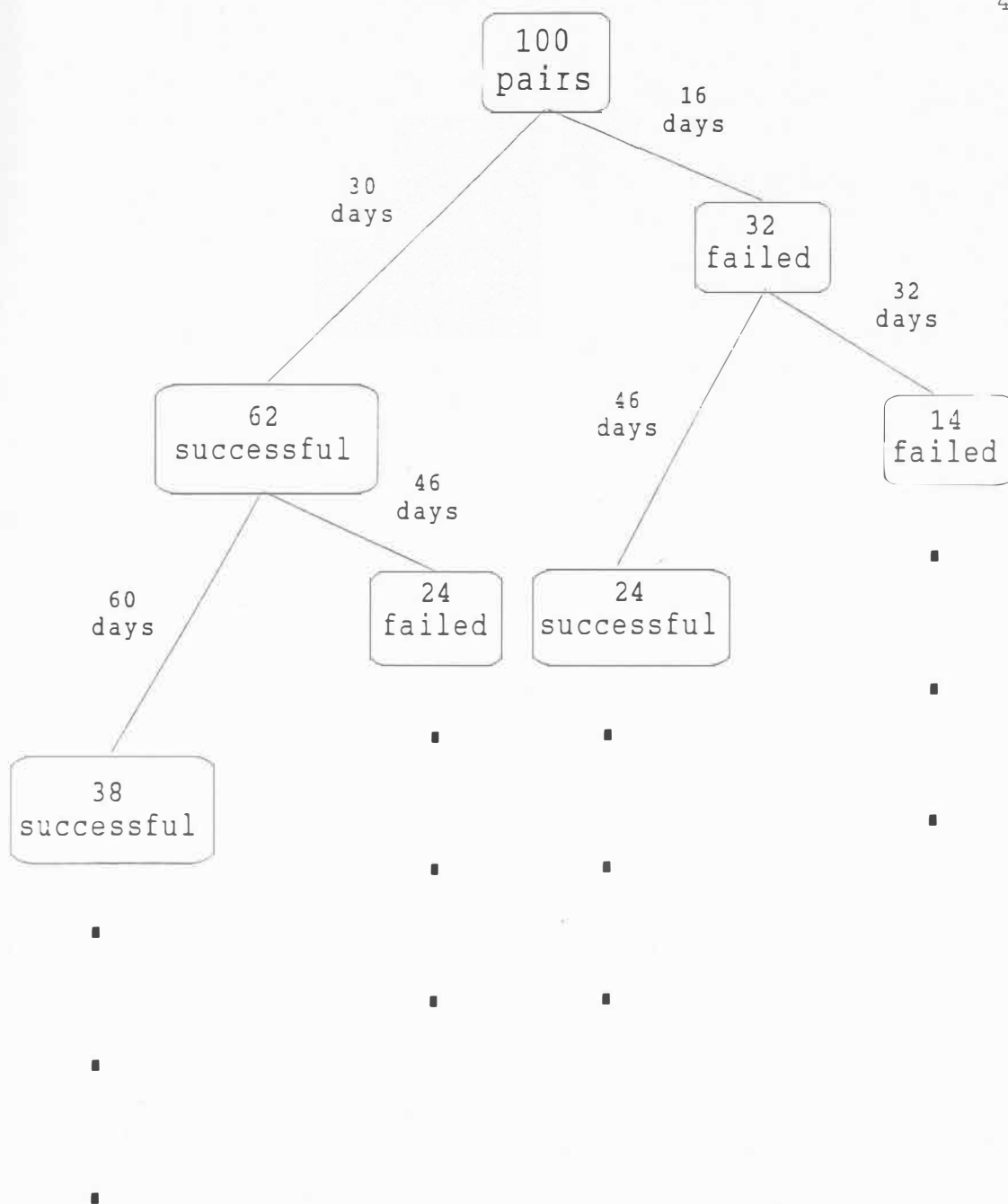


Figure 1. Partial flowchart of all combinations of possible reproductive events. Boxes indicate number of birds renesting and previous fate.

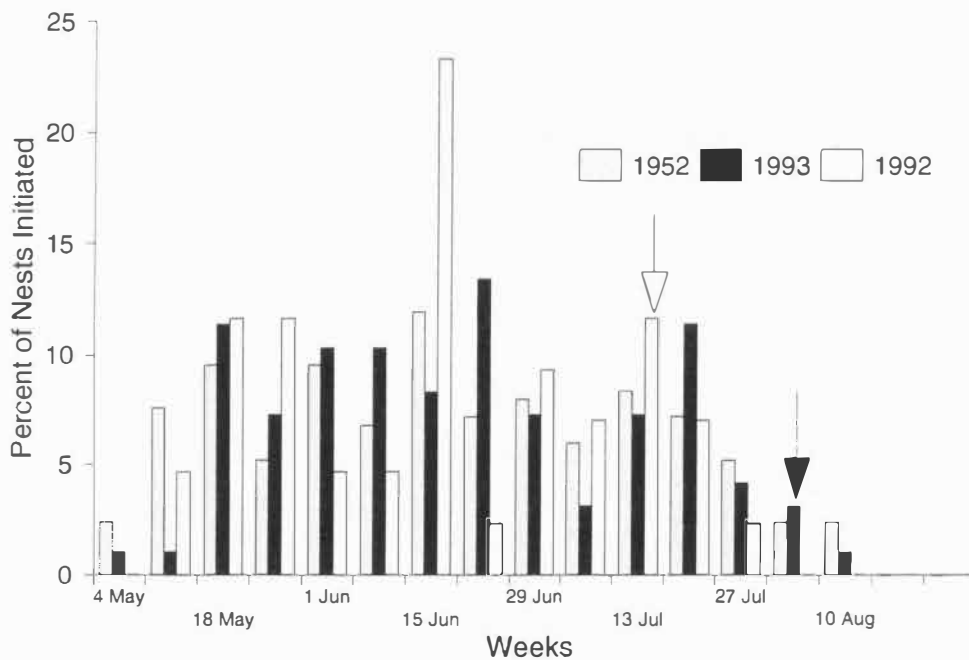


Figure 2. Proportion of mourning dove nests initiated during the breeding season. Fillmore, Utah. Each bar represents one week. Initiation defined as the first day eggs were laid. Arrows indicate beginning of grain harvest.

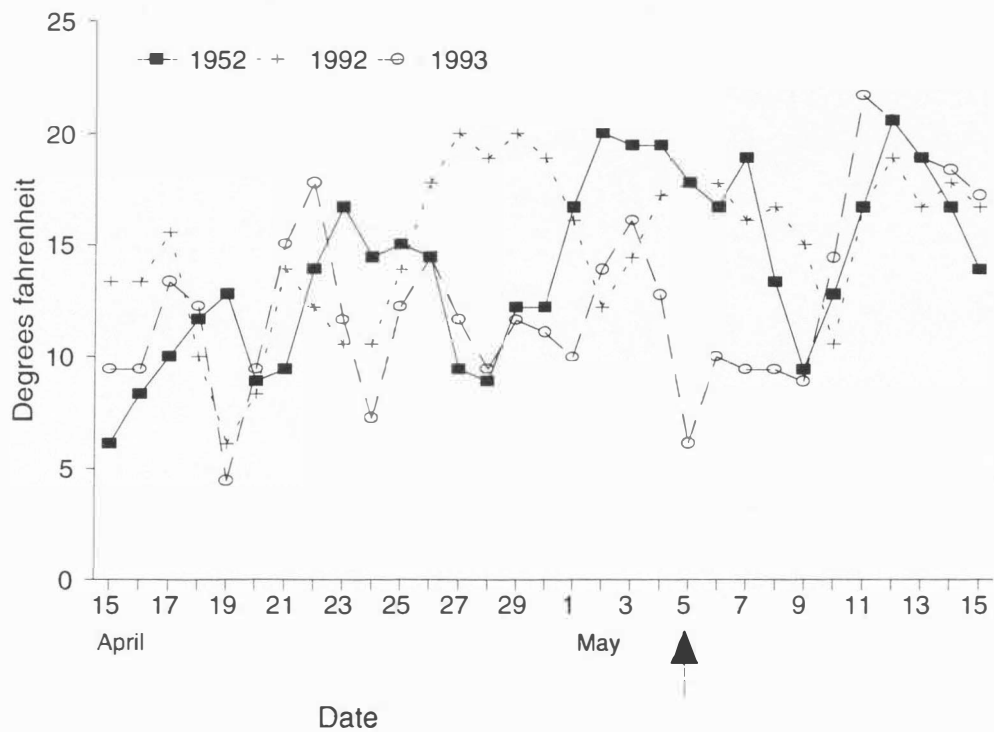


Figure 3. Mean daily temperatures during early breeding season. Fillmore, Utah. Arrow indicates first eggs laid.

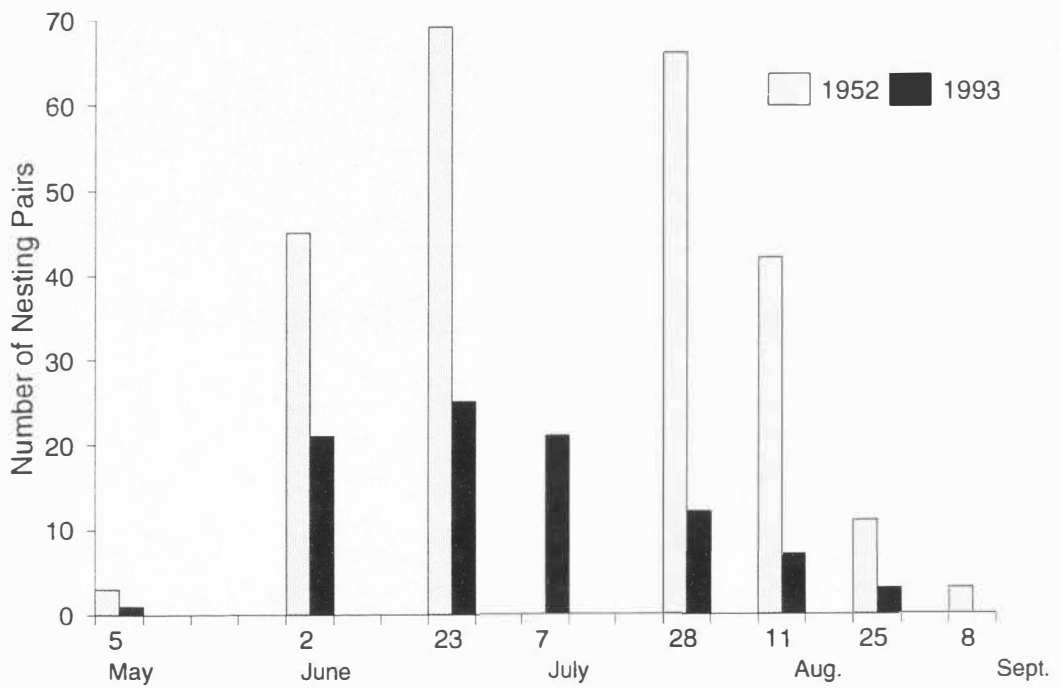


Figure 4. Number of mourning dove breeding pairs throughout the breeding season. Fillmore, Utah.

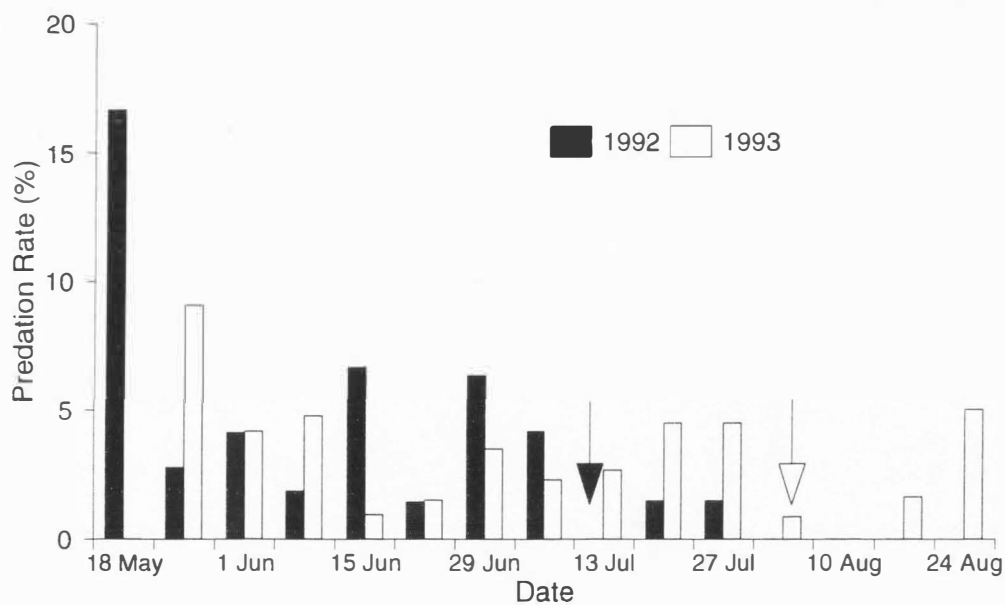


Figure 5. Nest predation rate throughout the breeding season. Fillmore, Utah. Predation presented as number of predation events each week divided by the number of nest-days in the week. Arrows indicate beginning of grain harvest.

EFFECT OF PERCH SITES ON HABITAT DISTRIBUTION
OF MOURNING DOVES (ZENAIIDA MACROURA)²

ABSTRACT.--I examined the effect of perch sites on Western Mourning Dove (Zenaida macroura marginella) breeding density and distribution in two ways. First, I demonstrated a significant correlation between nest density and perch site density in riparian plots. Second, I erected artificial perch sites the second year of the study and recorded the change in nest densities in plots that contained perch sites and in paired control plots. Nest density was higher in experimental plots than in control plots, but the difference was not statistically significant. From the levels recorded the previous year, however, nest densities increased in the experimental plots and decreased in the control plots. This difference was statistically significant, suggesting that Mourning Doves use the presence of perch sites as cues for habitat selection. I also found that the presence of Blackbirds (Agelaius phoeniceus and Euphagus cyanocephalus) and Western Meadowlarks (Sturnella neglecta) was significantly higher in experimental plots than in controls.

²Coauthors for this paper are Paul M. Meyers, Michael R. Conover, and John A. Bissonette.

Mourning Dove populations in the western U.S. have declined slowly over the past 29 years (Dolton 1994). Year to year, the population fluctuations are small, but over time the trend has shown a significant decrease. Although this species is one of the most abundant birds in the U.S. (Robbins et al. 1986), the persistent decline has created much concern. Of the three general populations that exist in the U.S. (Kiel 1959), the decline is only apparent in the western population--the central and eastern populations show stable trends.

The possibility exists that changes in habitat have created limitations affecting breeding density. Many habitat components have been listed as essential to sustain reproductive populations in birds: presence or absence of trees, available food, perch sites for singing, roosting, or foraging, nest material, nest sites, adequate water, and presence or absence of other organisms (Lack and Venables 1939, Hilden 1965, Klopfer and Hailman 1965). In addition, there are often indirect cues to habitat quality that are not in themselves important for survival but on which the birds rely for habitat selection (Lack 1933 and 1937, Hilden 1965, Wiens 1969, Fretwell 1972). This study was designed to test the importance of a single environmental factor, elevated perch sites, on the density and distribution of nesting Mourning Doves.

My own observations of Mourning Doves in southern Utah show that nests are invariably placed next to prominent perches protruding 2 m or more above the surrounding vegetation (P. Meyers unpubl.), and many researchers have speculated that perch sites are important components of avian habitat (Lack and Venables 1939, Kendeigh 1941, Hilden 1965, Zimmerman 1971, Wiens 1973, Knodel-Montz 1981, Castrale 1983). Mourning Doves use perch cooing to attract mates (Frankel and Baskett 1961, Jackson and Baskett 1964), and territorial birds in general rely heavily on singing for territorial defense (Welty 1982:280). While some birds have developed flight songs, Mourning Doves need perches from which to sing. Also, perch sites probably are important simply to monitor territorial intrusions and increase owner visibility. Jackson and Baskett (1964) stated that unless a bird is actually seen by the territory owner, the owner does not react, even if the intruder is cooing. If not absolutely necessary for species habitation, perch sites still may be important for reducing the amount of energy expended in territory maintenance.

Most studies that have investigated perch-site importance pertain to raptors (Stahlecker 1978, Stalmaster et al. 1979, Hall et al. 1981, Reinert 1984, Fielder and Starkey 1986, Buehler et al. 1992, Caton et al. 1992) and treat perch sites as foraging outlooks. Several researchers

examined perch site selection for grassland birds (Castrale 1983, Witter and Cuthill 1992) and for bill wiping in European Starlings, Sturnus vulgaris, (Harrison 1977). Kendeigh (1941) suggested that a lack of perch sites may have contributed to increased chasing for territorial defense in Yellow Warblers (Dendroica aestiva). A few studies, both descriptive and experimental, have looked at perch-site effects on the presence or density of birds during the breeding season (Lack 1933, Lack and Venables 1939, Harrison and Brewer 1979, and Knodel-Montz 1981). Finally, Downing (1959) found that Mourning Doves in northwest Oklahoma showed a much higher nest density in areas of trees, though he attributed this fact mainly to nesting substrate. I have found no studies that have tested the effect of perch sites on actual nest densities.

This study consisted of three parts. In the first, I correlated Mourning Dove nest density with the presence of perch sites. In the second, I examined the effect of artificial perch sites on Mourning Dove nest density. In the third, I compared the use of the perch-site areas by all species of birds to the use of a paired control plot.

STUDY AREA

The study took place about 2 km northwest of Fillmore, Utah, in an area called the Old Fields. These fields were

the first to be irrigated and farmed when the area was settled in the 1800's, and irrigation practices have changed little since that time. Chalk Creek, which ran through the site, was diverted into irrigation canals, and most of the farmland was irrigated by gravity flow.

The area was situated in a broad, arid basin (Pahvant Valley). Rainfall averaged 37.9 cm per year. The specific area of research consisted of approximately 12.6 km of riparian vegetation (8.1 km irrigation ditch and 4.5 km creek) running through approximately 570 ha of farmland. The riparian vegetation consisted of a fairly continuous line of shrubs interspersed with trees. A few small areas along the irrigation ditches contained a second-story, closed canopy, but most of the canals were typified by shrubby vegetation. The irrigation canals received periodic water flow throughout the summer while Chalk Creek dried up before data collection in 1992 and around 5 June in 1993.

Major vegetation in the irrigation canals consisted of willow (Salix sp.), squawbush (Rhus trilobata), wild rose (Rosa sp.), and golden currant (Ribes aureum). The major vegetation along Chalk Creek consisted of squawbush, interspersed in places with single, relatively tall (≥ 5 m) trees, such as willow (Salix sp.), cottonwood (Populus sp.), locust (Robinia sp.), and boxelder (Acer negundo).

Fields surrounding the canals consisted mostly of

alfalfa (Medicago sativa), wheat (Triticum aestivum), barley (Hordeum vulgare), and pasture--mainly rye grass (Lolium multiflorum). Unfarmed areas consisted of desert shrubs and grasses, including juniper (Juniperus utahensis), sagebrush (Artemisia tridentata), and cheatgrass (Bromus tectorum).

METHODS

Relationship Between Nest Density and Natural Elevated Perch Sites.--From 15 April to 5 September 1992 and 1 May to 5 September 1993, I searched for Mourning Dove nests once per week by walking the riparian areas and agitating the vegetation with a 2.5-m aluminum pole. On 19 July in the first field season, I expanded the census area due to low nest density. I plotted all nest locations after 19 July 1992, all nest locations in 1993, and all elevated perch sites 5 m or more in height on aerial photographs taken from a fixed-wing aircraft in 1992. The perch sites consisted mainly of trees but also included power lines and poles. I transferred all locations onto orthophotos, which are computer-manipulated photographs in which parallax is removed.

I partitioned all riparian areas into 200-m circular plots and recorded number of perch sites and number of nests in each plot. I excluded plots in which closed-canopy tree cover made up more than 25% of the plot, as these plots

added two variables--cover and an additional type of nest substrate. I compared nest density to tree density with a Pearson's correlation, and further examined the relationship in 400-m plots. I also measured linear distance of the riparian areas in each plot using orthophotos and a measuring wheel. I compared nest density to length of riparian vegetation with a Pearson's correlation.

Effect of Artificial Perch Sites on Nest Density.--

During the spring and summer of 1993, I constructed artificial perch sites in riparian areas. A pair of perches consisted of 2 5.1 x 5.1-cm stakes 4.3 m high with a 30-m length of wire running between them. Each plot contained two pairs of perches, one pair on each side of the riparian vegetation, offset 15 m. Wire was later replaced with three to five strands of polypropylene twine, twisted together. I ran a guide wire to the ground at each end to add support and increase line tension.

Some disagreement exists on Mourning Dove territory size (Lund 1952, Mackey 1954, Wing 1956:220). I chose to make plots 75 m long, which is within the range reported by Jackson and Baskett (1964) and Sayre et al. (1980). Data from the previous year showed the average distance from nest to nearest perch site was ($\bar{x} \pm SD$) 7.9 ± 10.8 m, so I ran plots 15 m beyond each end of the perch sites. Average width between the perch wires was 12.5 ± 5.6 m. Because of

land-use restrictions, one perch site consisted of two 20-m pairs, in a line, with a 5-m separation.

I chose areas that lacked adequate perch sites--areas without trees or power lines. I also avoided most fence lines. Plots began at least 50 m away from trees or power lines. I marked a starting boundary and randomly assigned it as the boundary of a control or an experimental area. I measured plots with a measuring wheel, and left a 50-m buffer zone between experimental and control plots. Due to the meandering nature of Chalk Creek, a consistent straight-line measure between stakes produced a varying creek length. Average plot length in Chalk Creek was 78 ± 5.6 m. I adjusted control plot boundaries to match experimental plots after I erected the perch sites.

Beginning 4 May, I erected perches in eight plots along Chalk Creek, eight along irrigation canals, and five in former pasture. Beginning 8 June, I erected 10 more sets in sagebrush habitat. In pasture and sagebrush, wire length was 20 m, and plots measured 60 m by 35 m. Width between perch wires was 5 m for seven sites and 25 m for eight sites. I chose points at random with a map and grid, gave the plot a random bearing, and began the paired plot 50 m in a random direction.

Once per week, using the same methods as for the nest census, I conducted nest searches in and beyond the plots

and buffers. I recorded only active Mourning Doves nests and compared total nests in the experimental plots to total nests in the control plots with a Wilcoxon's signed rank test for matched pairs.

Through the nest census in 1992, I collected data in 11 of the 16 riparian sites in the year before the experiment. I compared nest densities in the plots over the same time periods for both years. I analyzed the change within experimental plots with a Wilcoxon's sign rank test for matched pairs, in which pairs were the same plots in consecutive years. Finally, I compared the change in experimental plots to the change in the paired controls with a Wilcoxon's sign rank test for matched pairs.

To determine whether change in nest density in plots reflected an absolute change for the study area or a shift in distribution, I counted all nests between experimental plots and directly compared this number with nests in the same areas in 1992. I compared this change to the change that occurred within the experimental plots.

Artificial Perch Sites and Plot Use by Other Avian Species.--From 10 June-11 August 1993, I made weekly spot checks of plot use by walking from one end of the plot to the other and counting the number, species, and location (on the perch sites or elsewhere in the plot) of birds present. I checked all plots either on the same day or on two

consecutive days.

In addition to weekly checks, several plots were close enough to the road to accurately check during routine drives. Because these data weighted several areas too heavily, however, they are only included in species totals, but excluded from comparisons. Paired comparisons were made with a Wilcoxon's sign rank test for matched pairs.

Finally, I checked the perch sites specifically for Mourning Dove use as I drove the study site each day. I began bi-weekly evening checks for Mourning Doves late in the season (2 August). These checks began 1 hour before sunset.

RESULTS

Relationship Between Nest Density and Natural Elevated Perch Sites.--Mourning Dove nest density and tree density were significantly correlated ($r = 0.72$, $P < 0.0005$, $n = 33$, Fig. 6) for the study area. The relationship was stronger in Chalk Creek ($r = 0.85$, $P = 0.001$, $n = 11$, Fig. 7) than in the irrigation ditches ($r = 0.67$, $P = 0.001$, $n = 22$, Fig. 8). The correlation remained highly significant when I omitted plots that contained no nests ($r = 0.65$, $P < 0.0005$, $n = 24$), and strengthened when plot size was increased to 400 m ($r = 0.81$, $P = 0.003$, $n = 11$). Number of nests was not significantly correlated to the length of riparian

vegetation within the plots ($r = 0.14$, $P = 0.43$, $n = 33$).

Nearly all nests (78%, $n = 90$) were found in shrubs or on the ground. The correlation between nests and trees remained highly significant ($r = 0.61$, $P < 0.0005$, $n = 33$) with all tree-borne nests removed from analysis.

Effect of Artificial Perch Sites on Nest Density.--

Overall nest density in and around the experimental area was low. Plots in both sagebrush and former pasture contained no Mourning Dove nests. They did, however, contain three unidentified nests--two in experimental plots and one in a control plot. Because of this lack of response, these habitat types were not analyzed further.

In the riparian sites, I found nine Mourning Dove nests in the experimental plots, four in control plots, and five in buffer areas. Five of 16 (31%) experimental plots contained nests, and three of 16 (19%) control plots contained nests. One buffer plot was situated between two back-to-back experimental plots. I found two nests in this buffer, and it may have been influenced by the perch sites. For the year of the experiment only, the difference between nests in experimental and control sites was not statistically significant ($T = 5$, $P = 0.16$, $n = 6$).

The low magnitude of response made statistical power very low. I found no exact power test for a Wilcoxon's test, but I was able to calculate the power of the

parametric alternative--the paired t-test. For the mean difference experienced, power was 0.23. Power for the Wilcoxon's test is somewhat less, suggesting that the chance of actually detecting the difference I measured was very small. To achieve power of even 0.50, the P -value would have to be set at 0.23. Because of low power, I will consider statistical significance at $P = 0.1$ to reduce the chance of type II errors.

In the 11 plots censused during the pretreatment season, experimental plots contained two nests, and control plots contained four nests. After placement of the perch sites, experimental plots contained seven nests and controls two. The increase of nests in experimental plots was statistically significant ($T = 2$, $P = 0.09$, $n = 5$). I could not statistically analyze the change in control plot nests because all but two differences were zero (a Wilcoxon's test excludes ties, thus reducing sample size). But this result strongly suggests that no change occurred within control plots. The change in experimental plots was significantly higher than the change in control plots ($T = 2$, $P = 0.05$, $n = 6$).

The argument can be made that subsequent nests in the same plot may not be independent (i.e., they may be produced by the same pair that previously nested there). Three nests are in question. Two nests were in previous nests and were

probably made by the same pair. As one was in a control and the other in an experimental plot, P -values changed little when these nests were removed from analysis for both the within-year comparison ($T = 7$, $P = 0.15$, $n = 7$) and between-year comparison ($T = 2.5$, $P = 0.06$, $n = 6$). The most conservative estimate, when all three nests were removed from analysis, changed the within-year comparison slightly ($T = 6$, $P = 0.22$, $n = 6$) and had no further effect on the between-year comparison. In short, removal of these nests did not change the original results.

Seven of nine nests in experimental plots and two of four nests in control plots occurred within 50-110 m of two or more very large (more than 10 m in height) trees. This added variable produced three perch-site arrangements: tall trees with artificial perch sites, tall trees alone, and artificial perch sites alone. Kruskal-Wallis analysis showed a significant difference ($H = 6.40$, $P = 0.04$, $df = 2$) in number of nests among these three arrangements. Subsequent multiple comparison analysis, however, failed to detect significance between individual treatments. I used a nonparametric multiple comparison for unequal sample sizes (Zar 1984:200), and failure to detect a difference was probably due to reduction in power from the Kruskal-Wallis to the individual comparisons.

Descriptively, the combination of both tall trees and

artificial perch sites produced the highest nest density (seven nests in four plots or 1.75 nests per plot), followed by tall trees alone (two nests in three plots or 0.67 nests per plot), followed by artificial perch sites alone (two nests in 12 plots or 0.17 nests per plot).

From 1992-93, riparian sections between experimental plots showed a decline from 10 nests to seven (from seven to two in areas more than 50 m from experimental plots, and from three to five in areas adjacent to experimental plots). Nests in experimental plots increased from two to seven. Though the sample is small, this increase and corresponding decrease in nearby areas suggests a distribution shift occurred. However, the increase I saw within the experimental plots was greater than the decrease outside the plots (number of nests increased by five within experimental plots and decreased by three outside the plots). These data suggest that the increase I noted in the experimental plots was at least partly due to an absolute increase in number of nests.

Artificial Perch Sites and Plot Use by other Avian Species.--Many bird species used the experimental and control plots. A complete list in order of abundance (including those counts left out of the matched comparisons) includes Red-winged Blackbird, Brewer's Blackbird, American Robin (Turdus migratorius), Mourning Dove, Western

Meadowlark, Western Kingbird (Tyrannus verticalis), Red-tailed Hawk (Buteo jamaicensis), American Kestrel (Falco sparverius), Violet-green Swallow (Tachycineta thalassina), American Goldfinch (Carduelis tristis), Brown-headed Cowbird (Molothrus ater), and Black-billed Magpie (Pica pica). Because Red-winged Blackbirds and Brewer's Blackbirds were difficult to distinguish from a distance, but both were present in high numbers, I combined the counts from these two species.

Two groups, Blackbirds ($T = 0$, $P = 0.016$, $n = 7$) and Western Meadowlarks ($T = 0$, $P = 0.062$, $n = 10$), showed a significantly higher presence in the experimental areas than in the controls. When I excluded birds on the artificial perches, however, Blackbirds showed no significant difference ($T = 7.5$, $P = 1.0$, $n = 5$), suggesting that use of the natural vegetation in both plots was similar. Western Meadowlarks contained too many ties to analyze, suggesting that no difference existed also.

DISCUSSION

Relationship Between Nest Density and Natural Elevated Perch Sites.--Aside from trees, Chalk Creek contained a homogenous vegetation structure--mainly squawbush-lined banks--and was less influenced by human manipulation than were the irrigation ditches. The irrigation-ditch

vegetation, on the other hand, was managed by individual landowners and therefore often displayed radical vegetation shifts at property borders. The lower relationship between perch sites and number of ditch nests was likely due to this variation (i.e., many of the ditch plots may have contained marginal nesting habitat with perch sites, whereas all plots in the creek contained similar nesting vegetation, allowing a clearer indication of perch-site effects).

The fact that the correlation between number of nests and number of trees remained strong after the exclusion of tree-born nests from the data supports the hypothesis that trees were important mainly as perch sites rather than nest substrates. The correlation also remained strong after I excluded plots barren of nests. This test removed all plots unsuitable for nesting for reasons other than lack of perch sites. Finally, the relationship between number of nests and the length of riparian vegetation was not significant. This suggests that the actual area of nesting vegetation was probably not a cue to habitat quality--at least after a minimum threshold was present. Although type of nesting habitat may still be important, it seems clear that perch sites were an important common cue to habitat selection among different habitat types.

Effect of Artificial Perch Sites on Nest Density.--Nest density in riparian areas without plots (i.e., approximately

9.4 km riparian habitat throughout the study area) decreased 9.4% from 1992-93. This difference was slight but supports the evidence that the artificial perch sites had a positive effect on nest density. Because the plots represent a sample of the entire study area, if the perch sites had no effect, I should see this same drop in both the experimental and control plots. Density actually increased in experimental plots, though I observed a drop in the control plots.

The artificial perch sites produced high nest densities only in the presence of tall trees. Jackson and Baskett (1964) described a marked difference in perching behavior between mated and unmated males. Although both coo from perch sites, motivation for the behavior and the behavior itself differs. Unmated males do not defend a territory and utilize large areas (6-10 ha). Once mated, however, the male actively defends a small area (from 64 to 91 m in diameter), and begins to utter a nest coo, which is slightly different from a perch coo.

I propose that perch site requirements for these two behaviors may be different. Perch sites for mate attraction should be relatively tall so that a male can be seen and heard throughout a greater area. Therefore, Mourning Doves in my study site may select tall trees (primary perch sites from now on) during this stage of the reproductive cycle.

Once mated, however, the male need only defend a relatively small territory, which does not require tall perches, though some type of perch is necessary (secondary perch sites from now on). In areas where tall tree densities are low, doves may rely heavily on secondary perch sites in maintaining territories, though primary perch sites would still be important for mate attraction.

In the study area, I often noted Mourning Doves nest cooing on perches very near their nests. These perches were often only 1-2 m above the surrounding vegetation. Perch cooing, on the other hand, was most often heard near tree groups.

Lack of tall trees may explain the zero densities in many plots. Perch-site design probably contributed to low density also. The efficacy of the wire I used was questionable, and I suggest replacing the cross wire with a 0.5-1.0 m solid cross member, such as a wooden dowel. Of 11 birds seen on the rope, only two were further than a few meters from a stake. If a wire or rope is used, I suggest nothing smaller than 0.64 cm (1/4") in diameter and a material that is very stiff, such as cable. In addition, I recommend placing some plots near tree clusters and running the experiment for an additional season to rule out the effects of memory on returning birds.

The most practical management implication in light of

this study's results is to increase the density of primary perch sites. This can be done by planting trees and leaving dead trees standing. Placement of secondary perch sites alone may merely shift nest distribution without producing an absolute increase in nests. In a case where primary perch sites are limiting and secondary sites plentiful, construction of secondary perch sites will offer little increased reproduction. If secondary sites are limiting, however, their construction would improve densities.

Undoubtedly, perch sites are not the only cue important for nest-site selection. Although I found nests on the ground and in areas with no shrubs, densities in these areas were extremely low, indicating that perch sites alone do not define high quality nesting habitat.

As documented in chapter 1 and by Ostrand (1994), the Mourning Dove population for the Fillmore study site has declined between 1952 (Dahlgren 1955) and 1993. Tomlinson et al. (1988) has speculated that the loss of trees, especially phreatophytes, may play a part in the overall population decline in the western U.S. I have shown that trees play an important part in nesting ecology of Mourning Doves, but for reasons not usually attributed to them. Analysis of 1952 and 1993 aerial photographs indicates a reduction in mature trees from 116 to 85 at my study site. Ostrand (1994) further showed a 5% decrease in the amount of

shrubby riparian vegetation. Although my results indicate that a reduction in perch sites may cause a reduction in nesting population, this factor alone cannot entirely account for the reported 70-80% decline at my study site, and other factors must also be considered.

LITERATURE CITED

- BUEHLER, D. A., S. K. CHANDLER, T. J. MERSMANN, AND J. D. FRASER. 1992. Nonbreeding Bald Eagle perch habitat on the northern Chesapeake Bay. *Wilson Bull.* 104:540-545.
- CASTRALE, J. S. 1983. Selection of song perches by sagebrush-grassland birds. *Wilson Bull.* 95:647-655.
- CATON, E. L., B. R. McCLELLAND, D. A. PATTERSON, AND R. E. YATES. 1992. Characteristics of foraging perches used by breeding Bald Eagles in Montana. *Wilson Bull.* 104:136-142.
- DAHLGREN, R. B. 1955. Factors affecting Mourning Dove populations in Utah. M.S. Thesis. Utah State University, Logan. 93pp.
- DOLTON, D. D. 1994. Mourning Dove breeding population status, 1994. U.S. Fish Wildl. Serv., Laurel, MD. 19pp.
- DOWNING, R. L. 1959. Significance of ground nesting by Mourning Doves in Northwestern Oklahoma. *J. Wildl. Manage.* 23:117-118.

- FIELDER, P. C., AND R. G. STARKEY. 1986. Bald Eagle perch-sites in Eastern Washington. Northwest Sci. 60:186-190.
- FRANKEL, A. I., AND T. S. BASKETT. 1961. The effect of pairing on cooing of penned Mourning Doves. J. Wildl. Manage. 25:372-384.
- FRETWELL, S.D. 1972. Populations in a seasonal environment. Princeton Univ. Press, NJ. 217pp.
- HALL, R. R., W. E. HOWARD, AND R. E. MARSH. 1981. Raptor use of artificial perches. Wildl. Soc. Bull. 9:296-298.
- HARRISON, K. G. 1977. Perch height selection of grassland birds. Wilson Bull. 89:486-487.
- HARRISON, K. G., AND R. BREWER. 1979. The role of elevated perch sites and mowing in the distribution of grassland and savanna birds. Jack-Pine Warbler 57:179-183.
- HILDEN, O. 1965. Habitat selection in birds. Ann. Zool. Fenn. 2:53-75.
- JACKSON, G. L., AND T. S. BASKETT. 1964. Perch-cooing and other aspects of breeding behavior in Mourning Doves. J. Wildl. Manage. 28:293-307.
- KENDEIGH, S. C. 1941. Birds of a prairie community. Condor 43:165-174.
- KIEL, W. H., Jr. 1959. Mourning Dove management units--a progress report. U.S. Fish Wildl. Serv. Spec. Sci.

- Rep.--Wildlife 42. Washington, D.C. 24pp.
- KLOPFER, P.H., AND J.P. HAILMAN. 1965. Habitat selection in birds. Pages 279-303 in Advances in the study of behavior, vol 1. D.S. Lehrman, R.A. Hinde, and E. Shaw eds. Academic Press, New York.
- KNODEL-MONTZ, J. J. 1981. Use of artificial perches on burned and unburned tallgrass prairie. Wilson Bull. 93:547-548.
- LACK, D. 1933. Habitat selection in birds with special reference to the effects of afforestation on the Breckland avifauna. J. Anim. Ecol. 2:239-262.
- LACK, D. 1937. The psychological factor in bird distribution. Brit. Birds 31:130-136.
- LACK, D., AND L.S.V. VENABLES. 1939. The habitat distribution of British woodland birds. J. Anim. Ecol. 8:39-71.
- LUND, J. V. 1952. Nesting activities of the Eastern Mourning Dove in southern Michigan. M.S. Thesis. Michigan State College, East Lansing. 54pp.
- MACKEY, J. P. 1954. Some aspects of Mourning Dove behavior related to reproduction. M.S. Thesis. Ohio State University, Columbus. 101pp.
- OSTRAND, W. D. 1994. Factors affecting Mourning Dove population declines. M.S. Thesis. Utah State University, Logan. 76pp.

- REINERT, S. E. 1984. Use of introduced perches by raptors: Experimental results and management implications. Raptor Res. 18:25-29.
- ROBBINS, C. S., D. BYSTRAK, and P. H. GEISSLER. 1986. The breeding bird survey: Its first fifteen years, 1965-1979. U.S. Fish Wildl. Serv. Spec. Sci. Rep.--Wildl. 157. Washington, DC. 196 pp.
- SAYRE, M. W., T. S. BASKETT, and K. C. SADLER. 1980. Radio-telemetry studies of the Mourning Dove in Missouri. Mo. Dep. Conserv. Terrestrial Ser. 9. Jefferson City. 17pp.
- STAHLECKER, D. W. 1978. Effect of a new transmission line on wintering prairie raptors. Condor 80:444-446.
- STALMASTER, M. V., AND J. R. NEWMAN. 1979. Perch-site preferences of wintering Bald Eagles in Northwest Washington. J. Wildl. Manage. 43:221-224.
- TOMLINSON, R. E., D. D. DOLTON, H. M. REEVES, J. D. NICHOLS, AND L. A. MCKIBBEN. 1988. Migration, harvest, and population characteristics of Mourning Doves banded in the Western Management Unit, 1964-1977. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. No. 13. Washington, DC. 101pp.
- WELTY, J. C. 1982. The life of birds. 3rd ed. CBS College Publishing, New York. 754pp.

- WIENS, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. No. 8. 93pp.
- WIENS, J. A. 1973. Interterritorial habitat variation in Grasshopper and Savannah Sparrows. Ecology 54:877-884.
- WING, L. W. 1956. Natural history of birds: A guide to ornithology. Ronald Press Company, New York. 539pp.
- WITTER, M. S., AND I. C. CUTHILL. 1992. Strategic perch choice for bill-wiping. Anim. Behav. 43:1056-1058.
- ZAR, J. H. 1984. Biostatistical analysis. 2nd ed. Prentice Hall, Englewood Cliffs, NJ. 718pp.
- ZIMMERMAN, J. L. 1971. The territory and its density dependent effect in Spiza americana. Auk 88:591-612.

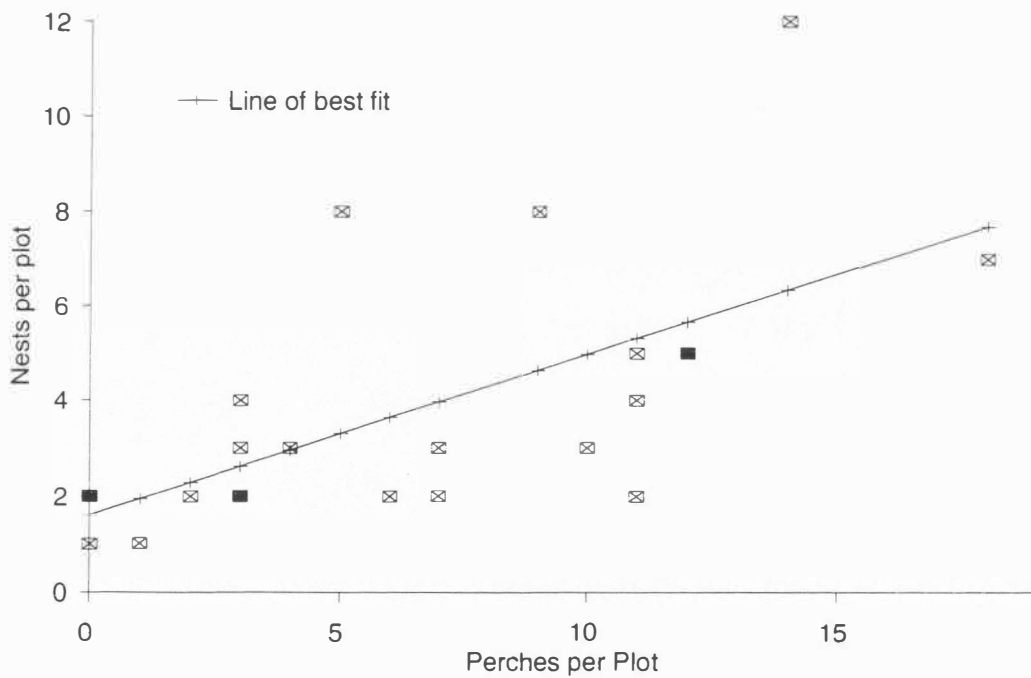


Figure 6. Number of nests and number of perch sites in 200-m plots. Fillmore, Utah. Black squares indicate 2 or more points.

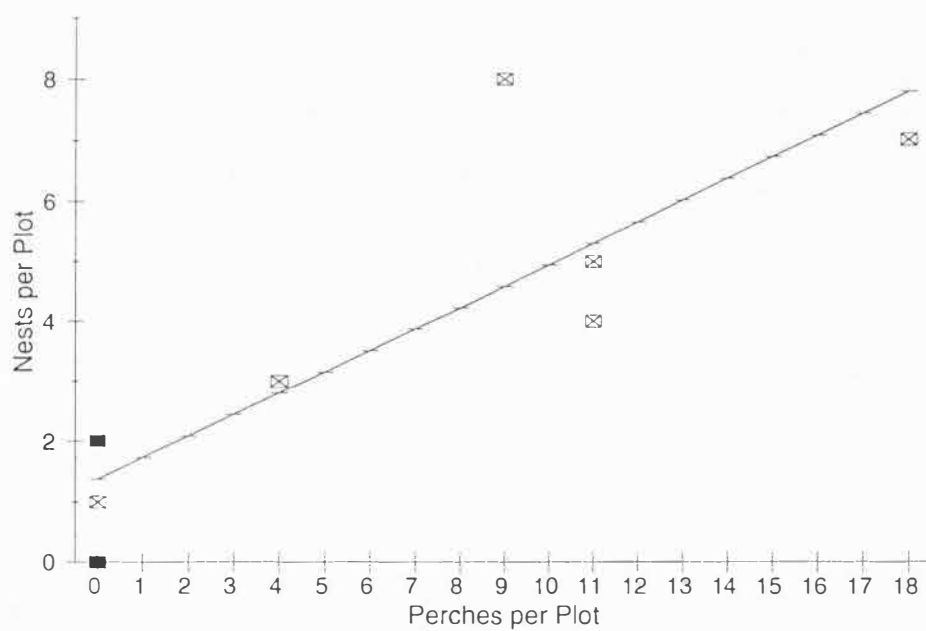


Figure 7. Number of nests and number of perch sites in 200-m plots in Chalk Creek only. Fillmore, Utah. Black squares indicate 2 or more points.

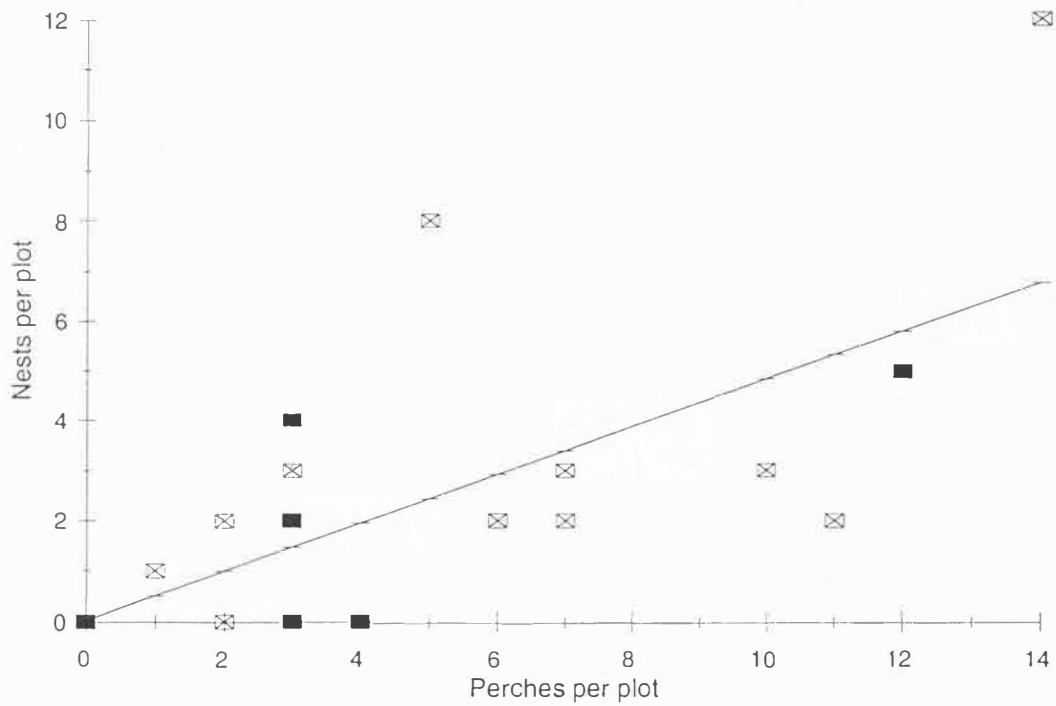


Figure 8. Number of nests and number of perch sites in 200-m plots in irrigation ditches only. Fillmore, Utah. Black squares indicate 2 or more points.

CONCLUSION

The nesting ecology of mourning doves in Fillmore, Utah has changed. I have shown that reproductive output has dropped since 1952 and is very likely the principal contributor to the population decline at my study site. I have further shown the importance of perch sites to dove breeding density and distribution. Future directions to rejuvenate dove populations are straightforward. First, we must discover the ultimate cause of lowered reproduction. The simplest and most cost-effective starting point is a broad screening of mourning doves for chlorinated hydrocarbons in fat tissue. This screening should be done early in the season when doves are just back from migration. If results are negative, a food limitation study should be initiated.

While studies are underway, specific management goals can be implemented. Landowners should be encouraged to plant trees and to leave dead trees standing. A shrubby understory for nesting should also be grown. Dead vegetation should not be removed, as it is valuable nesting substrate and creates effective perch sites. Also, planting of native seeds, such as bee weed, should be initiated.

Manipulation of reproduction has long been an effective

wildlife management tool. Studies such as this one, emphasizing reproduction and nest survival, tend to support this strategy. However, factors such as juvenile survivorship and overwinter mortality may be vitally important, though difficult to study and manage. Issues of this sort could not be addressed within the framework of this study, but they warrant consideration.

Aside from the management implications of this study, the scientific questions it raises are numerous. Questions on differing scales of habitat selection, scales of habitat distribution, and perch-site selection need further research to clarify. The question also arises of differences in inclusive fitness between defense of primary perch sites and the lowered energetic costs of switching to smaller secondary sites after mate selection.

Major questions arising from analysis of reproductive changes stem from alternative hypotheses for lowered reproductive output. Although I have proposed stress as the ultimate cause, many other possibilities exist. The study area may no longer be a primary nesting area, but may rest on the fringe of one (i.e., Fillmore itself). This change could lead to less fit individuals in my study area, producing the patterns I observed. Of radio-tagged birds trapped on the study area, 7 of 19 nested in town and only 3 nested within the study area. This may suggest a change in

primary nesting areas.

We did not consider the effects of hunting on the population. But perhaps more interesting than the effects of hunting mortality are the effects of hunting on genotype. If hunting has selected for skittishness, one may see an affect on reproduction, as flighty birds may abandon nests more frequently. In this study, abandonments were high, and normally effective trapping methods were unproductive because of premature flushing and long times of return to nests.

Finally, a lack of social facilitation may exacerbate low reproductive levels. Cooing behavior is stimulated by the cooing of other doves, and may stimulate reproductive activity. The lack of this aural stimulation may reduce reproductive vigor.

The scale of my study was small in relation to the scale of the population decline. A large-scale investigation, however, has more difficulty answering specific questions on life-history changes. It is hoped that additional small-scale studies focusing on season length, reproductive output, and symptoms of stress will indicate large-scale patterns.

APPENDICES

APPENDIX A. FIGURES

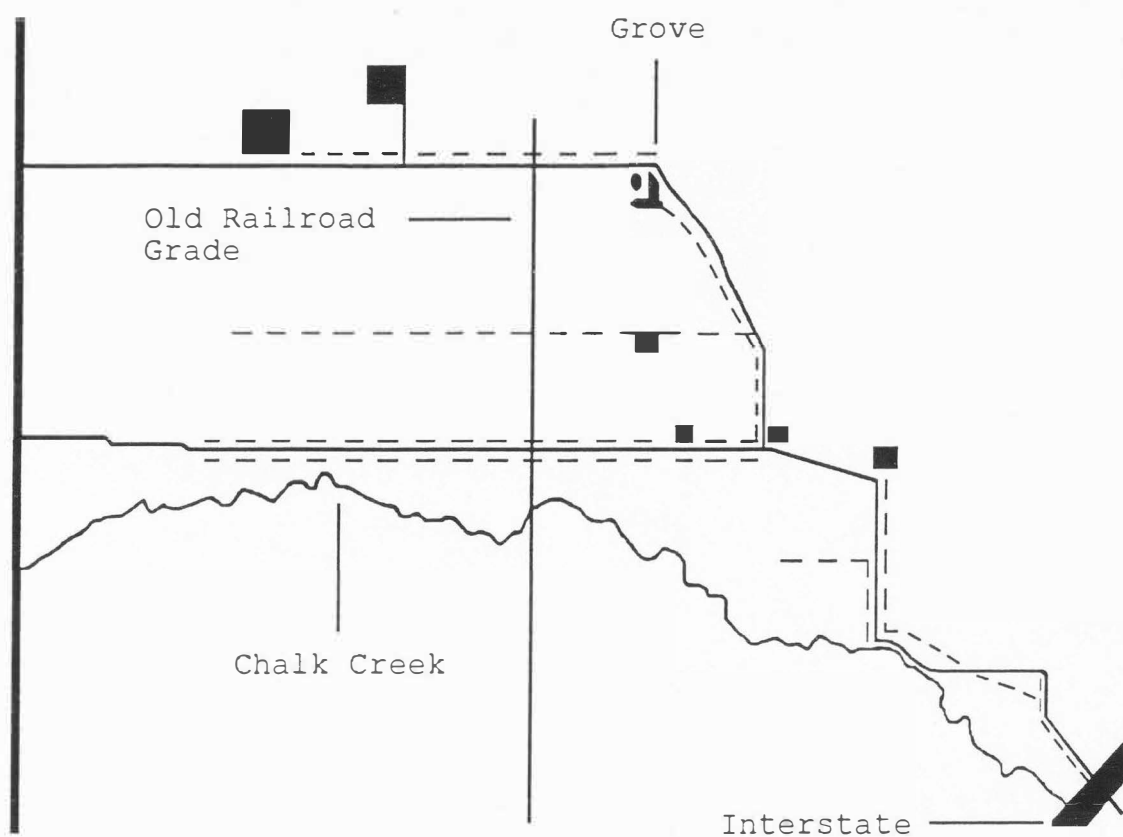


Figure 9. Map of study area. Dashed lines indicate ditches censused. Squares indicate farmyards, habitations, or abandoned farm sites.

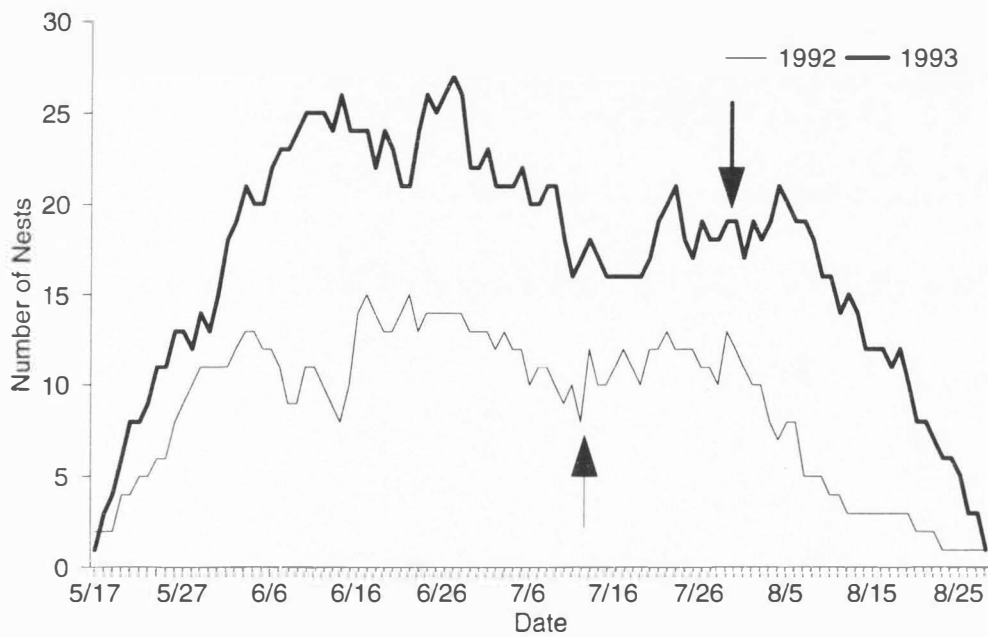


Figure 10. Number of occupied nests present throughout breeding season. Fillmore, Utah. Arrows indicate beginning of grain harvest.

APPENDIX B. LETTER OF PERMISSION

25 July 1994

I grant permission for Paul M. Meyers to include the chapter entitled "Assessing Mourning Dove Population Declines: Changes in Nesting Dynamics after 40 Years" in his M.S. thesis.

William D. Ostrand